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IDENTIFIERS	Oklahoma

ABSTRACT

This module on electricity is one of a series of modules designed to teach basic skills necessary for entry-level employment in this field. This module contains four instructional units that cover the following topics: (1) electrical materials; (2) electrical tools; (3) electrical layout; and (4) electrical basic skills. Each instructional unit follows a standard format that includes some or all of these eight basic components: performance objectives, suggested activities for the instructor, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. All of the unit components focus on measurable and observable learning outcomes and are designed for use in more than one lesson or class period. Each unit includes illustrations. (KC)

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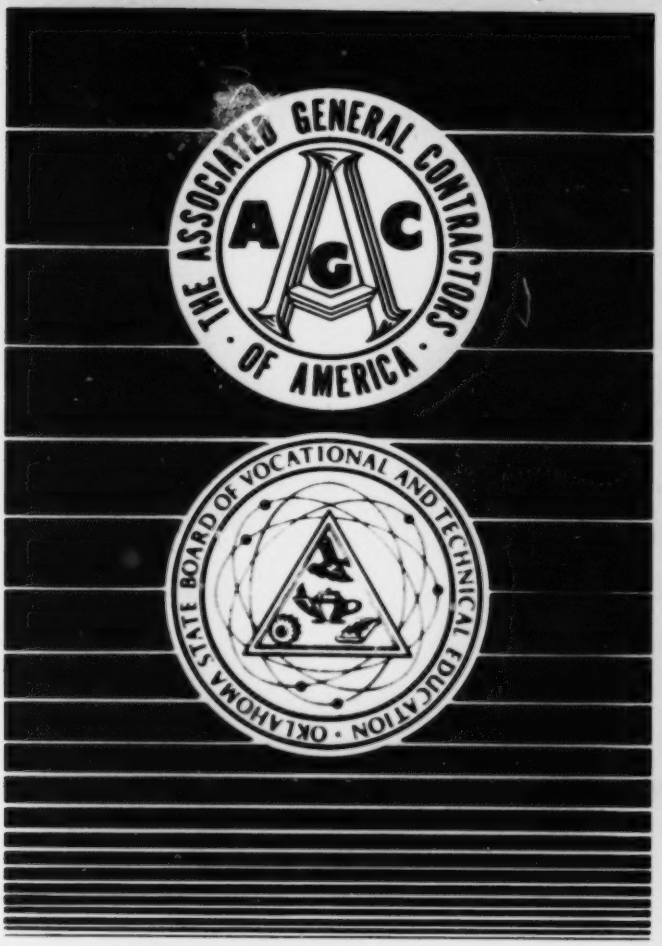

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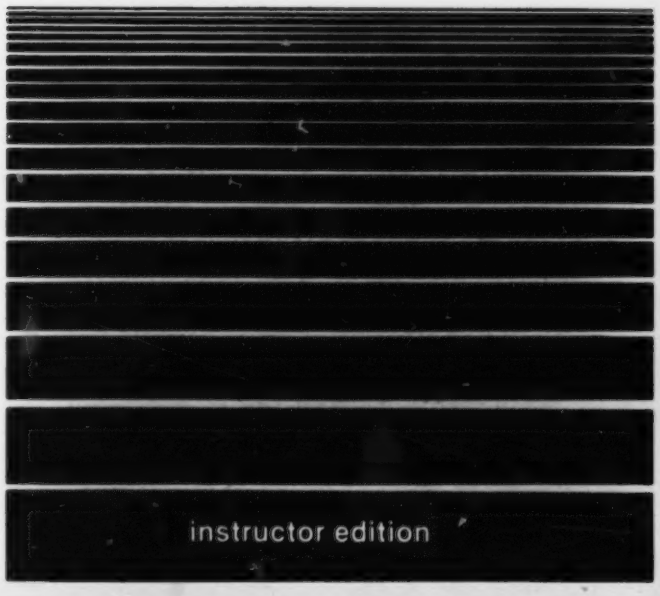

Introduction to Construction Series

CE 054 440

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INTRODUCTION TO ELECTRICITY
COMPETENCY PROFILE

Student_____ Soc. Sec. No. ___ – ___ – _____
Last First MI

PROGRAM _____ Grade 9 10 11 12 Adult SCHOOL _____

INSTRUCTOR _____ SCHOOL ADDRESS _____ PHONE _____

STUDENT'S HOME ADDRESS _____ DATE OF BIRTH _____ PHONE _____

STUDENT'S EMPLOYER _____ ADDRESS _____ PHONE _____

CONTACT IN CASE OF EMERGENCY _____ PHONE _____

ADDRESS _____

OR

ADDRESS _____ PHONE _____

The above information can be used for school records and/or to ensure safety of students. This confidential information is not to be released to employers or to the general public.

ON-JOB TRAINING/WORK EXPERIENCE

DURATION OF EMPLOYMENT	JOB TITLE	EMPLOYER	SUPERVISOR'S NAME	ADDRESS OF EMPLOYER	PHONE

This agency does not discriminate on the basis of race, creed, color, national origin, sex, age, veteran status, qualified handicap, or disability.

SPECIFIC JOB COMPETENCIES

Directions: Evaluate the trainee using the rating scale below and check the appropriate number to indicate the degree of competency achieved. The numerical ratings of 4, 3, 2, 1, and 0 are not intended to represent the traditional school grading system of A, B, C, D, and F. The descriptions associated with each of the numbers focus on level of student performance for each of the tasks listed below. The written test score line is provided for optional teacher use. It may not be applicable in all cases. "NA" is an appropriate entry in such instances.

Rating Scale:
4 — Skilled — can perform independently with no additional training.
3 — Moderately Skilled — has performed independently during training program; limited additional training may be required.
2 — Limited Practice — has practiced during training program; additional training is required to develop skill.
1 — Exposure Only — general information provided with no practice time; close supervision needed and additional training required.
0 — No Exposure — no information or practice provided during training program; complete training required.

---

4 3 2 1 0

☐☐☐☐☐ *Electrical Materials*
☐☐☐☐☐ 1. Install a set screw conduit fitting.
☐☐☐☐☐ 2. Install a liquid-tight conduit fitting.
☐☐☐☐☐ 3. Braid the neutral conductor of a service entrance cable.
☐☐☐☐☐ 4. _____

WRITTEN TEST SCORE _____

4 3 2 1 0

☐☐☐☐☐ *Electrical Tools*
☐☐☐☐☐ 1. Cut cable using side cut pliers.
☐☐☐☐☐ 2. Adjust wire strippers.
☐☐☐☐☐ 3. Trim conductor insulation using a knife.
☐☐☐☐☐ 4. Use a soldering gun to slice conductors.
☐☐☐☐☐ 5. Use a knockout punch.
☐☐☐☐☐ 6. Bend a 90-degree stub with ½" EMT.
☐☐☐☐☐ 7. Cut rigid conduit with a pipe cutter.
☐☐☐☐☐ 8. Set up and use a hacksaw.
☐☐☐☐☐ 9. Ream rigid conduit.
☐☐☐☐☐ 10. Use a volt ohmmeter.
☐☐☐☐☐ 11. _____

WRITTEN TEST SCORE _____

4 3 2 1 0

☐☐☐☐☐ *Electrical Layout*
☐☐☐☐☐ 1. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a floor plan.
☐☐☐☐☐ 2. Locate receptacle outlets along kitchen counters on a floor plan.
☐☐☐☐☐ 3. Install a device box when given cabinet height and wall coverings.
☐☐☐☐☐ 4. Install a lighting outlet box when given wall covering thickness.
☐☐☐☐☐ 5. Install a box with drywall grips in a drywall wall.
☐☐☐☐☐ 6. Secure a box with drywall supports (Boxtins).
☐☐☐☐☐ 7. Install a box in a concrete block wall.
☐☐☐☐☐ 8. Install a box in a ceiling with an accessible attic.
☐☐☐☐☐ 9. _____

WRITTEN TEST SCORE _____

4 3 2 1 0

☐☐☐☐☐ *Electrical Basic Skills*
☐☐☐☐☐ 1. Wire a single pole switch controlling a single lighting outlet with the supply line entering the switch box.
☐☐☐☐☐ 2. Wire a single pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box.
☐☐☐☐☐ 3. Wire a three-way switching situation with the supply entering a single lighting outlet.
☐☐☐☐☐ 4. Install a duplex grounding type receptacle.
☐☐☐☐☐ 5. Install a multi-circuit, split-wired duplex grounding type receptacle.
☐☐☐☐☐ 6. Wire a switch-controlled, split-wired receptacle.
☐☐☐☐☐ 7. Wire a receptacle fed from a lighting outlet through a single pole switch.
☐☐☐☐☐ 8. Install an overhead raceway with service entrance conductors to a meter base.
☐☐☐☐☐ 9. Connect meter base assembly to load center or panel.
☐☐☐☐☐ 10. Install plates on devices.
☐☐☐☐☐ 11. _____

WRITTEN TEST SCORE _____

Use of This Document

This document can be used to record information about the student and the skills mastered by the student. This information is useful in documenting student progress during the training program and to provide information about the student's qualifications to potential employers and for entry into advanced training programs. Instructors using AGC-CIMC instructional materials are authorized to reproduce this document as required for use in their training programs.

INTRODUCTION TO ELECTRICITY

Developed as a Cooperative Project by
The Associated General Contractors of America
and
Oklahoma State Department of Vocational and Technical Education

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INTRODUCTION TO ELECTRICITY

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FOREWORD

In 1985, The Associated General Contractors of American (AGC) met with representatives of the Oklahoma Curriculum and Instructional Materials Center (CIMC) to discuss the possibilities of developing, as a cooperative project, a course of instruction designed for training individuals who choose to seriously explore careers in construction.

This publication is the result of those original discussions and close coordination among general contractors and vocational educators. This series represents a conscious effort to coordinate the practical experience of personnel in the construction industry with the best instructional methods of those in the field of vocational education.

Although this series reflects a systematic approach to instructional materials development and the latest in educational technology innovations, the information in *Introduction to Electricity* should be adapted and modified to coincide with local conditions.

Roy Peters, Jr., Director
Oklahoma State Department of
Vocational and Technical Education

William K. Healy, Chairman
Manpower and Training Committee
The Associated General Contractors
of America

PREFACE

For many years The Associated General Contractors of America (AGC) has recognized the need for providing quality competency-based instructional materials for the construction industry. AGC and the Oklahoma State Department of Vocational and Technical Education have met this challenge by providing nationally recognized curriculum and services since 1972. In 1986 AGC and Oklahoma's Curriculum and Instructional Materials Center (CIMC) determined a significant need for a series that would address training needs of open shop contractors, pre-apprenticeship programs, multi-craft high school programs, technology educational programs, CVET, and cooperative education programs. The Introduction to Construction Series was designed with the flexible training requirements of these groups in mind.

The introduction to Construction Series begins with *Fundamentals of Construction* and progresses to twelve spin-off specialty publications. *Fundamentals of Construction* covers basic knowledge necessary for all individuals in construction. Each specialty area covers basic skills necessary for entry-level employment. Both vocational education and the construction industry offer more advanced courses in each specialty area and should be considered by individuals wishing to establish careers in the industry. Competency profiles (provided in the teacher edition) for the Introduction to Construction Series articulate with several more advanced AGC publications as well as publications developed by the Mid-America Vocational Curriculum Consortium (MAVCC).

Publications in this series include:

- Introduction to Bricklaying
- Introduction to Carpentry
- Introduction to Concrete Masonry
- Introduction to Concrete Reinforcing
- Introduction to Electricity
- Introduction to Plumbing
- Introduction to Heating, Ventilation, and Air Conditioning
- Introduction to Sheet Metal
- Introduction to Roofing
- Introduction to Drywall
- Introduction to Insulation
- Introduction to Welding

Instructional Units

Introduction to Electricity contains four instructional units. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters and supplements, tests, and answers to tests and assignment sheets. Depending on the specific objectives, there may or may not be transparency masters, supplements, assignment sheets, or job sheets, included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help him or her determine the following

- Amount of material that can be covered in each class period
- Skills that must be demonstrated
  - Supplies and equipment needed
  - Amount of practice needed
  - Amount of class time needed for demonstrations
- Supplementary materials, such as pamphlets and filmstrips, that must be ordered
- Resource people to contact

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the performance necessary to reach the unit objective. Since the objectives of the unit provide direction for the teaching/learning process, it is important that teachers and students have a common understanding of the intent of the objectives.

The objective sheet should be given to students and referred to throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine students' prior knowledge and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

Suggested activities are included only in teacher materials. The suggested activities pages include an outline of the unit contents and an instructor's guide designed to assist teachers in planning their presentation of the unit. The instructor's guide provides suggestions for delivery and/or presentation during the instructional process. Read the suggested activities

before teaching the units so that supplemental materials can be obtained, audiovisual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed in the suggested activities are ones used in the development of each unit. They may be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

The suggested activities section of the unit also includes supplements and transparency masters. Each of these components provides information in a special way. Supplements may consist of motivational materials, review or practice materials such as crossword puzzles and self-tests, or charts and reference materials. Supplements are designed to be copied and distributed to individual class members or to the class as a whole. Suggestions for their use are included in the instructor's guide. Transparencies direct the class' attention to the topic of discussion. Transparencies may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification or analysis is necessary. Order transparencies from the Curriculum and Instructional Materials Center, or make transparencies and place them in the notebook where they will be immediately available for use.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical-outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience. They assist students in the application of knowledge that are necessary pre-requisites to skill development. Assignment sheets may be given to the student for completion in class or may be used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or teacher for checking student progress. The scores of those assignment sheets listed in the specific objectives should be averaged with the unit test score, as the skills addressed in these assignment sheets are considered necessary in meeting the unit objectives.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

The teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might

reasonably expect from a person who has had this vocational instruction.

Job sheet performance should be evaluated by the instructor and averaged with the unit test score, as the skills addressed in the job sheets are considered necessary in meeting the unit objective.

Tests (white pages)

Tests are included only in teacher materials. The test provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, 80 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score and evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

Answers to test and assignment sheets are components designed to assist the teacher in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center (CIMC) is assigned a specific abbreviation. For example, *Introduction to Electricity* has been abbreviated ITE. The units are then numbered consecutively within each section. An example of a page number is ITE-1. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

For best results, provide student materials for each student. Student materials contain everything but the test, supplements, answers to assignment sheets, and suggested activities.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

Competency Profiles

Competency profiles are folders used to document student performance. The profile contains a list of the specific job competencies that a student should achieve prior to leaving the training program. A competency profile master is provided in the instructor edition of each publication. Duplicate the profile and distribute to students as required.

Other AGC Publications: AGC updates curriculum products on a continuing basis. For a free catalog describing other AGC products, call the AGC National office at 1-202-393-2040.

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. You can mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Coordinator for Curriculum Development
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and
Technical Education
1500 West Seventh Avenue
Stillwater, Oklahoma 74074

ELECTRICAL MATERIALS
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to identify various types of materials used in construction wiring. The student will show this ability by completing the unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with electrical materials to their correct definitions.
2. Write the particular conductor insulation designated when given the type letter.
3. Discuss size classifications of conductors.
4. List types of cables commonly found in construction.
5. List facts about cords and their conductors.
6. Identify wiring materials used in construction.
7. Identify boxes used in construction wiring.
8. Identify devices commonly used in construction wiring.
9. Identify covers and plates used in construction wiring.
10. Identify common supports and anchors.
11. Identify common screws, bolts, nuts and nails.
12. Identify common connectors, terminals and lugs.
13. Label types of safety switch enclosures.
14. Identify common load center accessories.
15. List possible installations for load centers.
16. Identify the parts of a fusible load center.

SPECIFIC OBJECTIVES

17. Identify the parts of a breaker load center.
18. Demonstrate ability to
    a. Install a set screw conduit fitting.
    b. Install a liquid tight conduit fitting.
    c. Braid the neutral conductor of a service entrance cable.

ELECTRICAL MATERIALS
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Transparency masters

1. TM #1 — Overcurrent Protection Devices
2. TM #2 — How a Fuse Works
3. TM #3 — How a Time Delay Fuse Works
4. TM #4 — How a Circuit Breaker Works

D. Information sheets

E. Job sheets

1. Job Sheet #1 — Install a Set Screw Conduit Fitting
2. Job Sheet #2 — Install a Liquid Tight Conduit Fitting
3. Job Sheet #3 — Braid the Neutral Conductor of a Service Entrance Cable

F. Test

G. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Material and equipment catalogs

(NOTE: Obtain several catalogs and display for students to review.)

SUGGESTED ACTIVITIES

EXAMPLES: Holub Catalog, ITT Holub Industries, Sycamore, Illinois; Raco Steel Box Catalog, Raco, Inc., South Bend, Indiana; Leviton Catalog, Leviton Manufacturing Co., Brooklyn, NY.

2. Samples of materials and accessories

3. Transparencies and competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Provide students with objective sheet.

D. Discuss unit and specific objectives, explaining the importance of being able to identify the various types of materials.

E. Provide students with information sheets.

F. Discuss information sheets.

1. Use Information Sheet, Section I, to discuss terms and definitions associated with electrical materials.

   - Have students review and discuss the terms and definitions.
   - Point out the importance of knowing the terms and definitions for common understanding.

2. Use Information Sheet, Section II, to discuss type letter designations for conductor insulations.

   - Have the students review the information.

3. Use Information Sheet, Sections III and IV, to discuss size classifications of conductors and types of cables used in construction.

   - Discuss the various sizes of conductors, where and how they are used.
   - Discuss how some conductors are used as small single wires and how some are wrapped together to form large cables.
   - Discuss where various sizes of cables may be used.

SUGGESTED ACTIVITIES

- Display various sizes of individual conductors and cables. Have students compare the very small conductors against the larger ones, then compare them against the large size cables.

4. Use Information Sheet, Section V, to discuss cords and their conductors.

   - Explain the importance of wiring systems being grounded.
   - Discuss why and how extension cords, tools, appliances, etc., are grounded.
   - Show students samples of the cords and grounding identifications found on the cords such as in Section V of the information sheet.

5. Use Information Sheet, Section VI, to discuss wiring systems used in construction.

   - Discuss where and why the various systems are used, and explain that the lighter systems, such as non-metallic sheathed cable, PVC, flexible metal conduit and the low voltage systems are generally used in residential construction while the heavy duty systems are used more in commercial construction.

6. Use Information Sheet, Sections VII through IX, to discuss the various types and sizes of boxes, devices, covers and plates used in construction wiring.

   - Discuss where the various sizes of boxes are used, how some are used for devices while others are used as junction boxes where splices are made and still others are used as outlet boxes for different types of fixtures.
   - Discuss locations of different types of boxes, such as switch boxes, outlet boxes, special devices such as dryers, air conditioners and electric stoves.
   - Discuss types of wall plates for switches and outlets, compare the plain plastic type to the more exotic types such as hardwoods and ceramic.

7. Use Information Sheet, Sections X through XII, to discuss supports, anchors, screws, nuts, bolts, nails, staples, connectors, terminals and lugs.

   - Display examples of the various electrical accessories.
   - Discuss how, where and why each of these accessories are used.

SUGGESTED ACTIVITIES

- Allow students to handle these accessories and demonstrate how to use them.

8. Use Information Sheet, Sections XIII through XV, to discuss safety switch enclosures, load center installations and accessories.

   - Display samples of each type of enclosure and load center discussed in the information sheet. Discuss how and why they are used; discuss the types and locations of installations.

   - Demonstrate the procedures for attaching the accessories, then have each student demonstrate these procedures.

9. Use Information Sheet, Sections XVI and XVII, to discuss parts of a fusible and a breaker load center.

   - Display a sample of each type of load center. Point out the differences to the students.

   - Discuss overcurrent protection and short circuits; show students types of overcurrent protection devices; use Transparency #1 — Overcurrent Protection Devices to reinforce your discussion.

   - Discuss how fuses and circuit breakers work. Use Transparencies #2, #3, and #4 to reinforce your discussion.

G. Give test.

H. Critique test and discuss in class.

I. Reteach and retest as necessary.

J. Complete appropriate section of competency profiles.

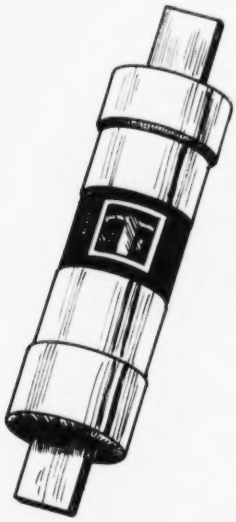
III. Unit references

A. Taylor, Mark. *Residential Wiring.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., rev. ed. 1983.

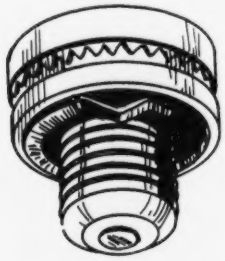
B. Taylor, Mark. *Residential Wiring.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., rev. ed. 1988.

Overcurrent Protection Devices

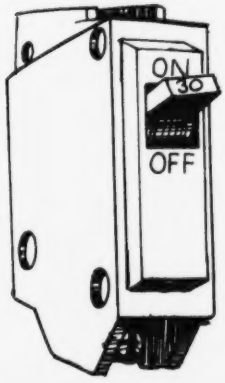
Ferrule Type
Cartridge Fuse



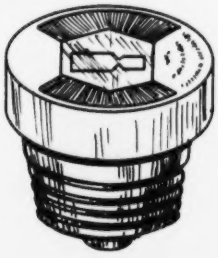
Blade Type
Cartridge Fuse



Type "S" Plug Fuse

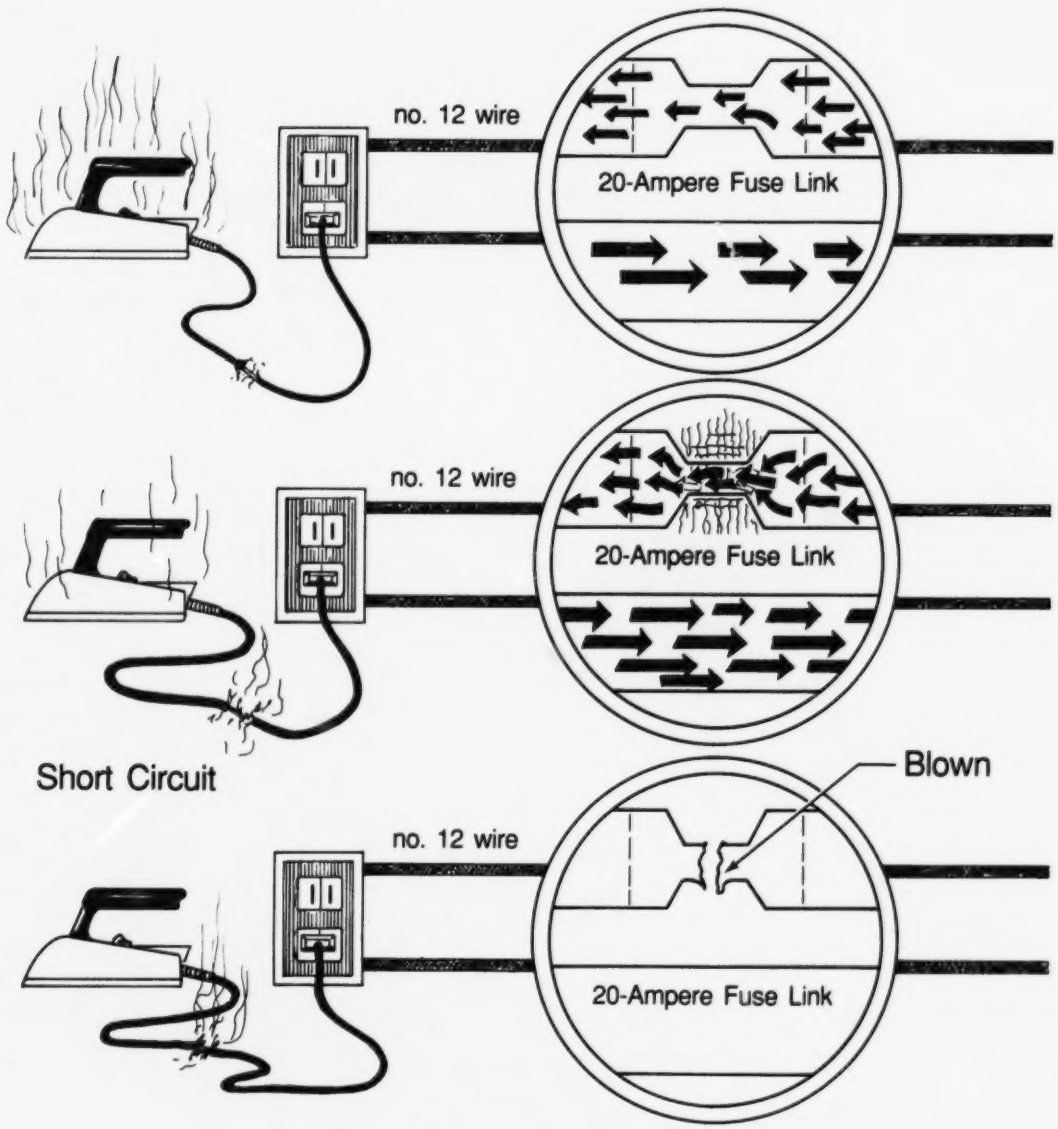


Circuit Breaker

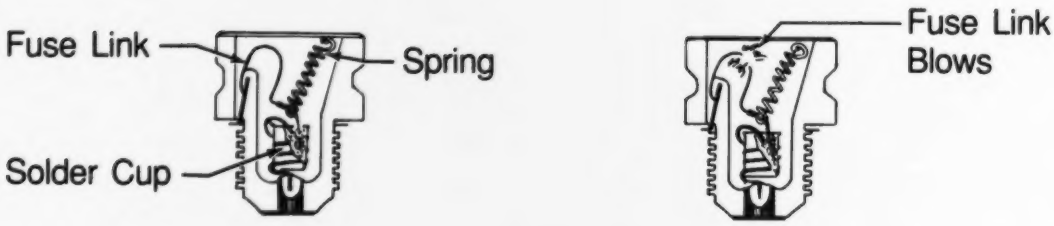


Edison Base Plug Fuse

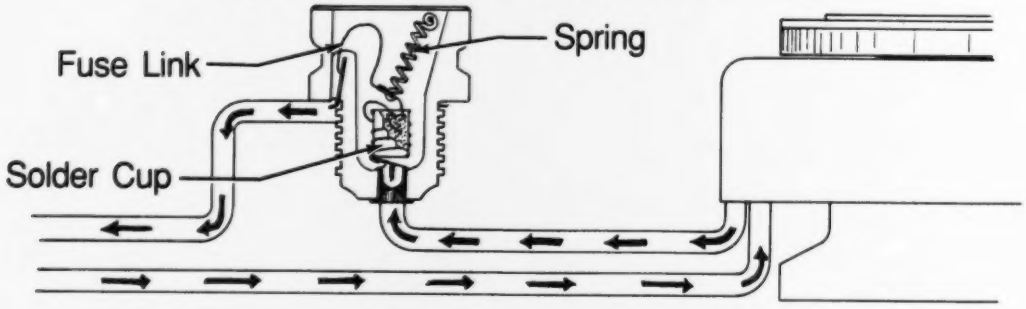
How a Fuse Works

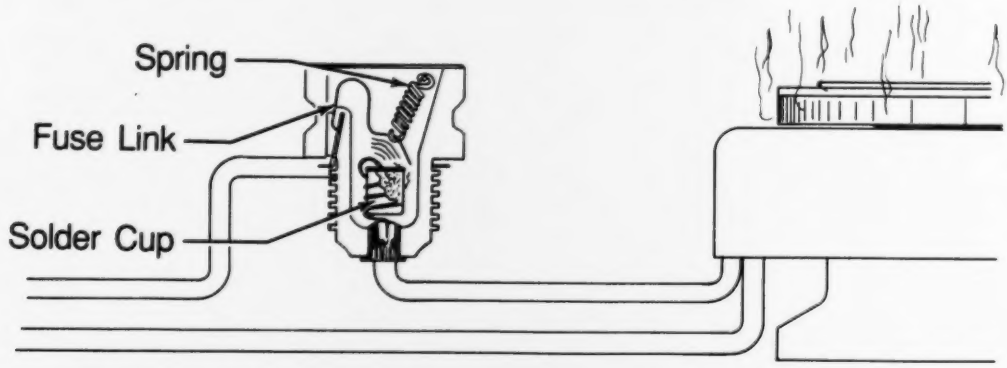


How a Time Delay Fuse Works



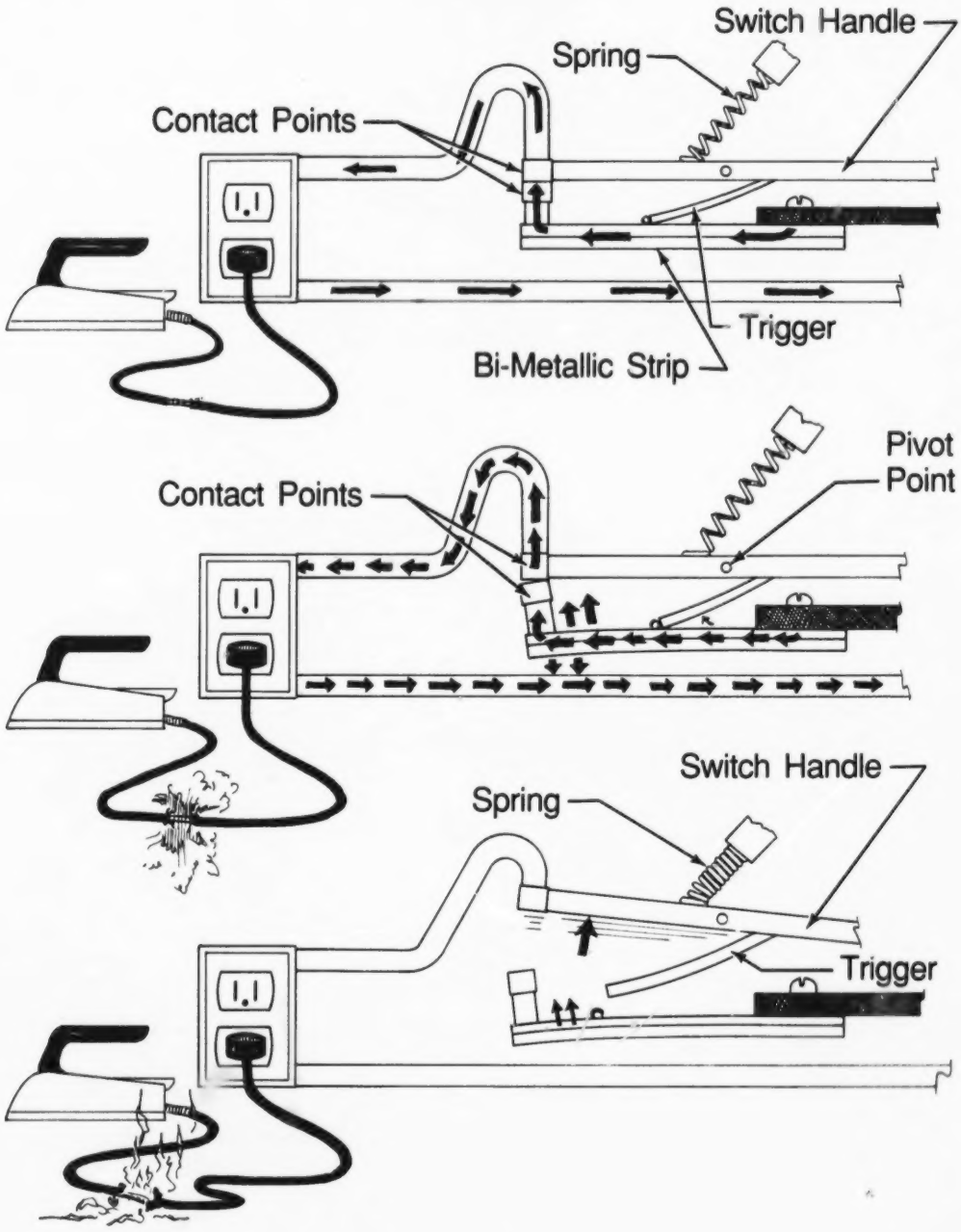
Temporary Overload Causes Solder to Heat





Continued Overload Softens Solder - Spring Pulls Fuse Link

How a Circuit Breaker Works



ELECTRICAL MATERIALS
UNIT I

INFORMATION SHEET

I. Terms and definitions associated with electrical materials

A. **Cable** — Two or more conductors grouped together in an overall covering

B. **Circuit** — Complete path for current to flow from source through the load and back to the source

C. **Circuit breaker** — Switch that automatically interrupts an electric circuit under an infrequent abnormal condition

D. **Circular mils** — The diameter of a conductor in thousandths of inches multiplied times itself

E. **Conductor** — Material which permits the free flow of electrons

F. **Device** — Electrical equipment that carries or transfers current but does not use it

G. **Low-voltage system** — Wiring system of less than 50 volts originating at a transformer

H. **Mil** — One thousandth of an inch

I. **NEMA** — National Electrical Manufacturer's Association; organization responsible for the setting of specifications for the various classes of enclosures

J. **NEMA Type 1** — General-purpose enclosure for indoor use under usual service conditions

K. **NEMA Type 3R** — Common residential outdoor enclosure

(NOTE: The **R** stands for raintight and signifies that the enclosure will not exclude wind-blown dust.)

L. **Receptacle** — Mounted, female electrical fitting that contains the live parts of the circuit

M. **Surface raceways** — System designed for surface installations

N. **Switch** — Device used to open or transfer circuit direction

INFORMATION SHEET

O. **Transformer** — Electrical device used to step up or step down a primary voltage to a desired secondary voltage

P. **Type letter** — Identification accepted by the trade in referring to a particular type of insulation

II. Type letter designations for conductor insulations

A. R — Rubber

B. T — Thermoplastic

C. W — Moisture resistant

D. H — Heat resistant

E. N — Nylon jacket

F. X — Cross-linked polymer

III. Size classification of conductors

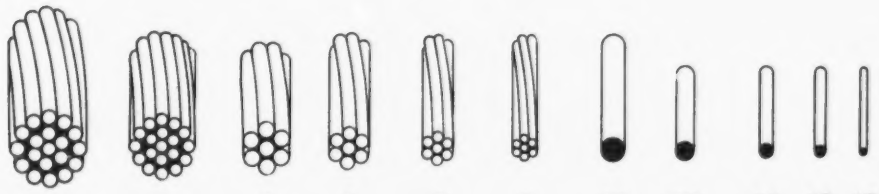
A. American wire gauge (AWG)

1. AWG is a standard size classification in the United States for copper and aluminum wires used in electrical construction

2. AWG gets up to 0000

EXAMPLE:

FIGURE 1 SIZE OF CONDUCTORS



ACTUAL DIAMETERS OF TYPICAL SIZES OF ELECTRIC WIRES WITHOUT INSULATION

INFORMATION SHEET

B. Thousand circular mils (MCM)

1. MCM is the standard size classification for conductors larger than 0000
2. MCM classifications go up to 2,000 MCM

IV. Types of cables commonly found in construction

A. Nonmetallic sheathed cable (NM)

B. Service-entrance cable (SE)

C. Low-voltage cable

D. Underground cable (UF)

E. Underground service-entrance cable (USE)

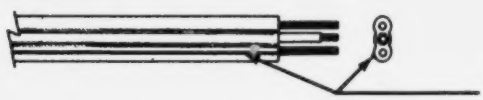
V. Facts about cords and their conductors

A. Cords used in a grounded system must have an identified grounded conductor

(NOTE: Article 400-22 (a) through (f) from the NEC [National Electrical Codes] describes acceptable methods for identifying grounded conductors.)

EXAMPLES:

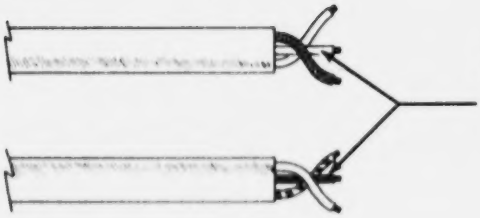
FIGURE 2



A ridge is used on many flat cords to identify the grounded conductor

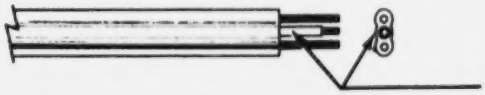
INFORMATION SHEET

FIGURE 3



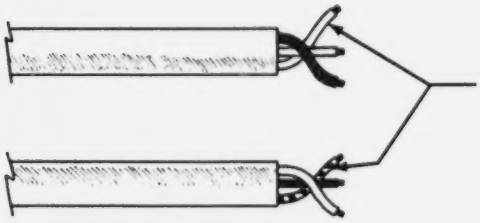
A white or natural gray braid or molded insulation is often used on round cords.

FIGURE 4



A central conductor with green insulation is often included in flat cords as a grounding conductor

FIGURE 5



A green or green and yellow striped braid or molded insulation is often used in round cords to identify a grounding conductor

B. Cords which have a conductor with green or green with yellow striped insulation shall use that conductor for grounding purposes only

C. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors

D. Cords should be used within their amp and insulation rating or classification

INFORMATION SHEET

VI. Wiring systems used in construction

A. Non-metallic sheathed cable system (Romex)

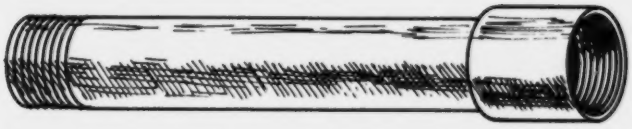
FIGURE 6

Connector

Staple

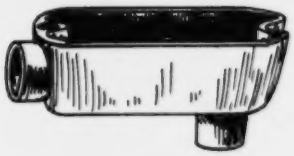
B. Rigid metal conduit system

FIGURE 7



Metal Conduit and Coupling

One-Hole Strap



Conduit Body

INFORMATION SHEET

C. Electrical metallic tubing system (EMT)

FIGURE 8

Electrical Metallic Conduit

EMT Coupling

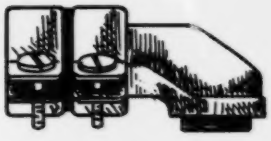
One-Hole Strap

EMT Connector

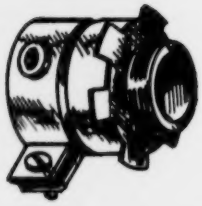
D. Flexible metal conduit system

FIGURE 9

Flexible Metal Conduit



90° Connector

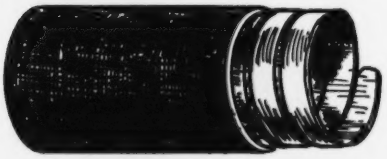


Straight Connector

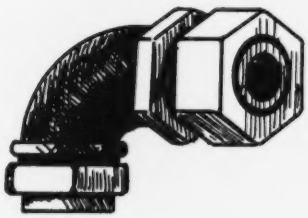
INFORMATION SHEET

E. Liquid tight flexible metal conduit system

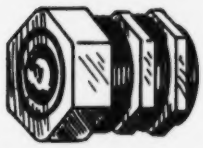
FIGURE 10



Liquid Tight Flexible Metal Conduit



90° Connector

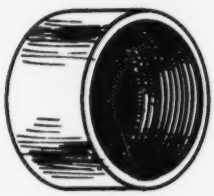


Straight Connector

F. Polyvinyl chloride conduit system (PVC)

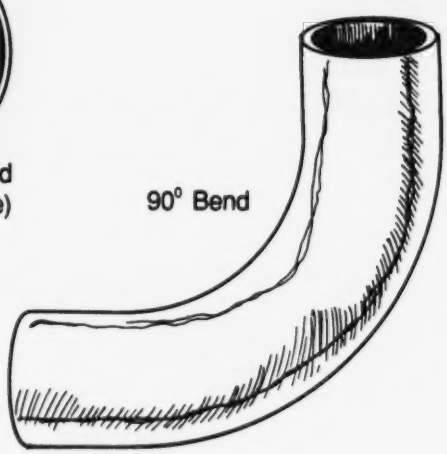
FIGURE 11

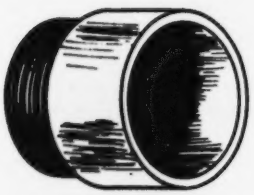
PVC Conduit



PVC to Threaded Adapter (Female)

90° Bend



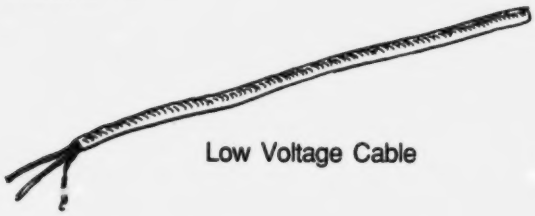


PVC to Threaded Adapter (Male)

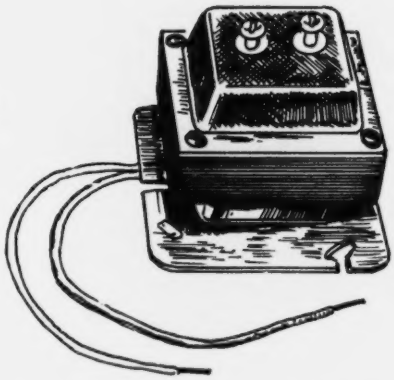
INFORMATION SHEET

G. Low voltage system

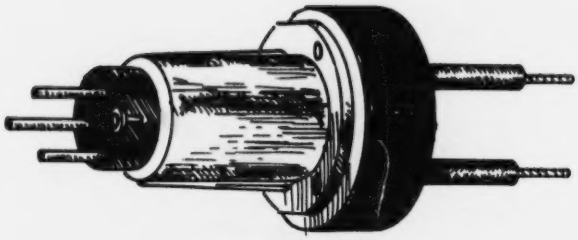
FIGURE 12



Low Voltage Cable



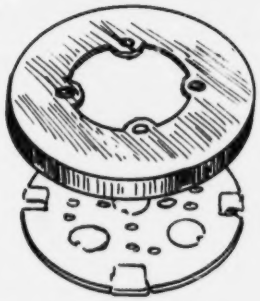
Low Voltage Transformer



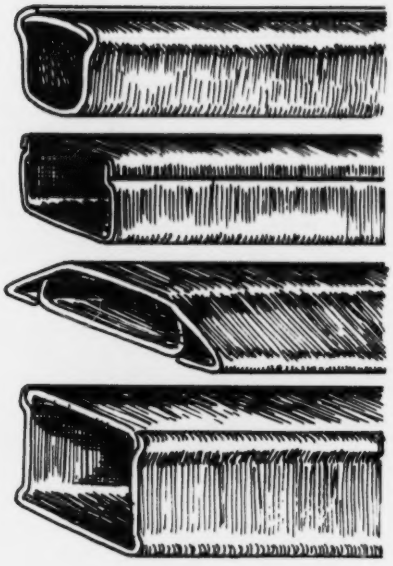
Low Voltage Relay

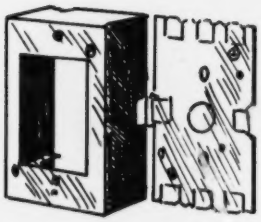
H. Surface raceway system

FIGURE 13



Surface Lighting Outlet





Surface Device Box

Surface Raceways

INFORMATION SHEET

VII. Boxes used in construction wiring

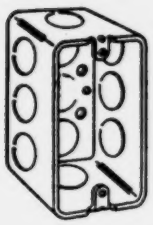
A. Device boxes

(NOTE: Most boxes can be purchased in either metal or non-metallic composition [fiber, plastic, nylon or rubber].)

1. Handy boxes

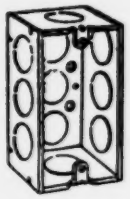
a. Molded construction

FIGURE 14



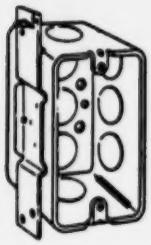
b. Welded construction

FIGURE 15



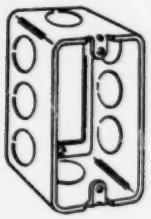
c. Bracket box

FIGURE 16



d. Extension

FIGURE 17



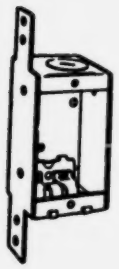
(NOTE: Extensions can be purchased for all types of boxes.)

INFORMATION SHEET

2. Switch boxes

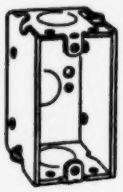
a. Bracket nongangable with cable clamps

FIGURE 18



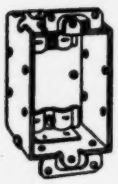
b. Gangable with nail holes

FIGURE 19



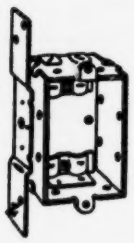
c. Gangable with ears and cable clamps

FIGURE 20



d. Gangable bracket box with cable clamps

FIGURE 21



e. With drywall grips, cable clamps, and ears

FIGURE 22

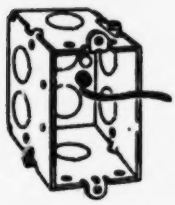
f. Beveled corner with cable clamps

FIGURE 23

INFORMATION SHEET

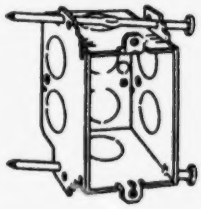
g. Gangable with grounding pigtail

FIGURE 24



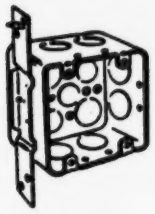
h. Nail-on type

FIGURE 25



i. Solid two-gang bracket

FIGURE 26



(NOTE: These are just a few of the types available. Configurations such as drywall grips, brackets, pigtails, and factory nail assemblies can be purchased on almost any size box.)

INFORMATION SHEET

B. Octagon boxes

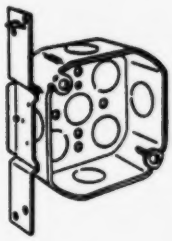
(NOTE: Octagon boxes, like switch boxes, can be either metallic or non-metallic. They can be purchased in many different depths.)

1. With cable clamps and nail holes

FIGURE 27

2. With bracket

FIGURE 28

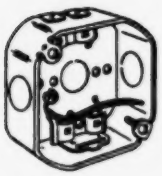


3. Extension

FIGURE 29

4. With cable clamps and grounding pigtail

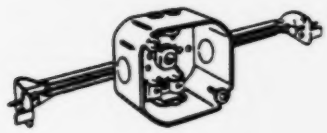
FIGURE 30



INFORMATION SHEET

5. With bar hanger and cable clamps

FIGURE 31

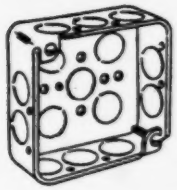


C. Square boxes

(NOTE: Square boxes are usually used in conjunction with covers designed for special purposes.)

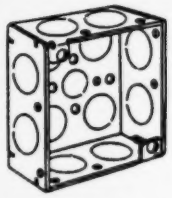
1. Molded construction

FIGURE 32



2. Welded construction

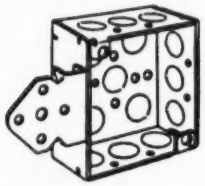
FIGURE 33



INFORMATION SHEET

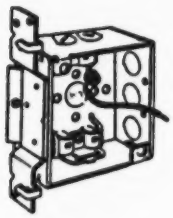
3. With bracket

FIGURE 34



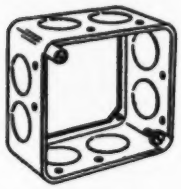
4. With bracket, cable clamps, and grounding pigtail

FIGURE 35



5. Square box extension

FIGURE 36



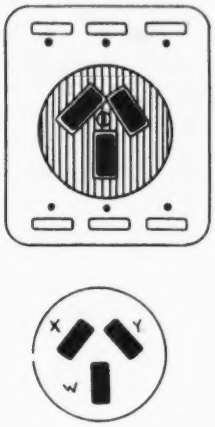
INFORMATION SHEET

VIII. Devices commonly used in construction wiring

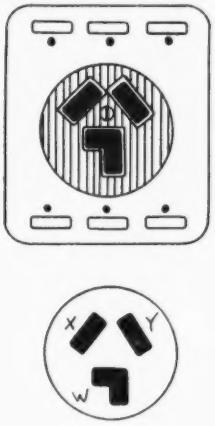
(NOTE: Manufacturers make different grades of devices. Price and quality vary with the grades. Specification grade is the most expensive. Before installing devices check the grade requested in the job bid.

A. Receptacles

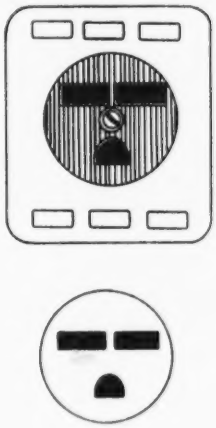
1. Range receptacle
   125/250V; 50 amp
   FIGURE 37



2. Dryer receptacle
   125/250V; 30 amp
   FIGURE 38



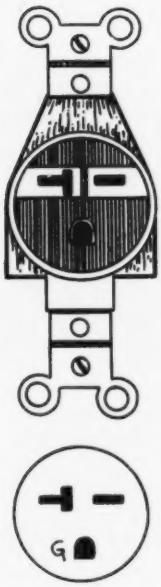
3. Air conditioning receptacle
   250V; 30 amp
   FIGURE 39



INFORMATION SHEET

4. Air conditioning receptacle 250V; 20 amp

FIGURE 40

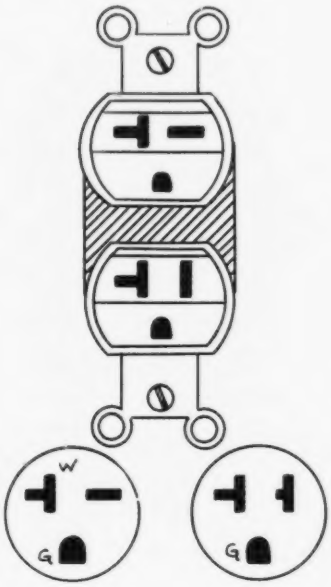


5. Duplex grounding receptacle 125V; 15 amp

FIGURE 41

6. Dual voltage receptacle 125/250V; 20 amp

FIGURE 42

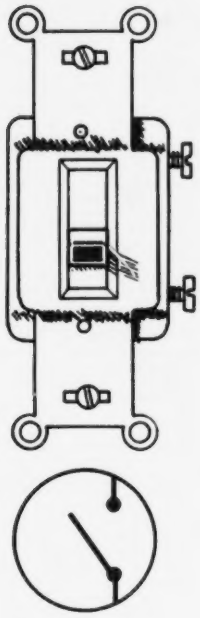


INFORMATION SHEET

B. Switches

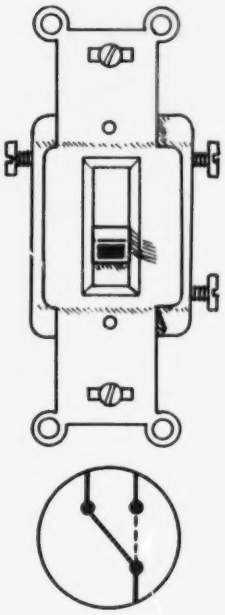
1. Single pole

FIGURE 43



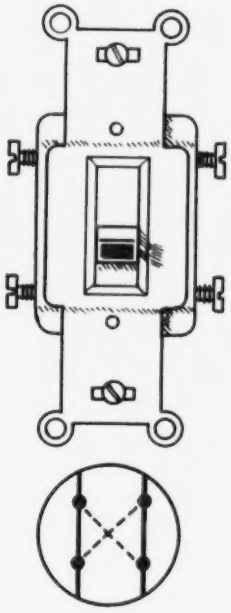
2. Three way

FIGURE 44



3. Four way

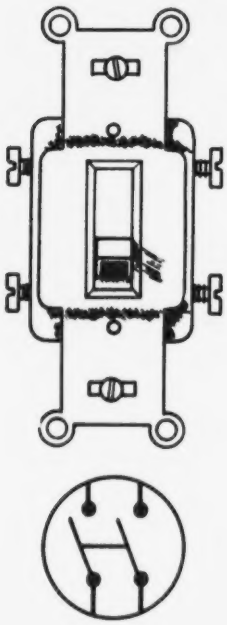
FIGURE 45



INFORMATION SHEET

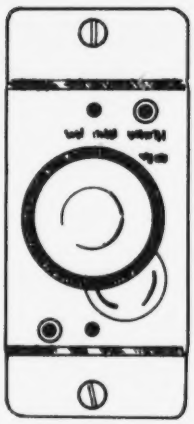
4. Double pole

FIGURE 46



5. Dimmer

FIGURE 47



6. Low voltage push button

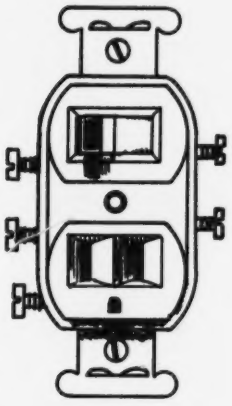
FIGURE 48

INFORMATION SHEET

C. Combination devices

1. Switch and receptacle

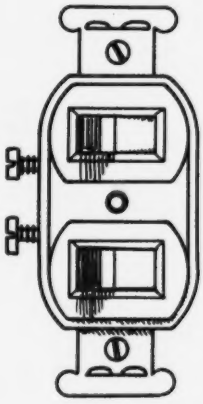
FIGURE 49



(NOTE: This can be a single pole or three way with a grounding type receptacle.)

2. Two switches

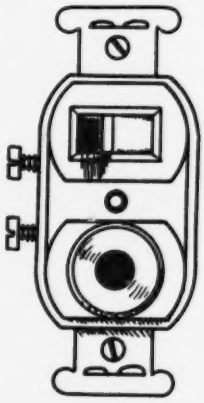
FIGURE 50



(NOTE: This can be two single poles, two three ways, or a single pole and a three way.)

3. Switch and pilot light

FIGURE 51



(NOTE: This can be either a single pole or three way with either a neon or incandescent light.)

INFORMATION SHEET

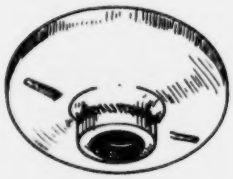
D. Sockets

1. Keyless pigtail

FIGURE 52

2. Keyless cover

FIGURE 53

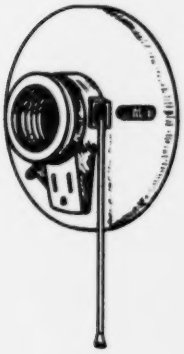


3. Pull chain cover

FIGURE 54

4. Pull chain cover with grounding type receptacle

FIGURE 55



INFORMATION SHEET

IX. Covers and plates used in construction wiring

A. Round covers

1. Flat blank

FIGURE 56

2. Flat with knockout

FIGURE 57

3. Raised with knockout

FIGURE 58

4. Raised for single device

FIGURE 59

5. Raised open

FIGURE 60

6. Flat toggle

FIGURE 61

7. Flat duplex

FIGURE 62

8. Flat single receptacle

FIGURE 63

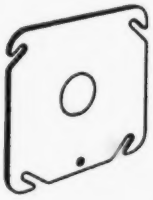
B. Square covers

1. Flat blank

FIGURE 64

2. Flat blank with knockout

FIGURE 65



3. Raised open

FIGURE 66

4. Flat single device

FIGURE 67

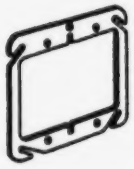
INFORMATION SHEET

5. Raised single device

FIGURE 68

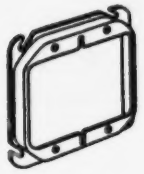
6. Flat two devices

FIGURE 69



7. Raised two devices

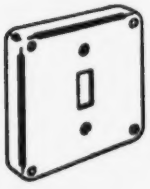
FIGURE 70



C. Exposed work raised square covers

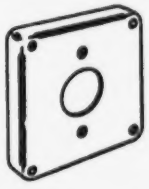
1. Single toggle switch

FIGURE 71



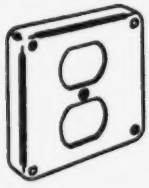
2. Single receptacle

FIGURE 72



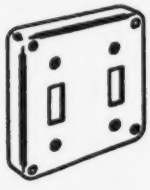
3. Duplex receptacle

FIGURE 73



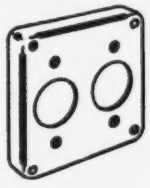
4. Two toggle switches

FIGURE 74



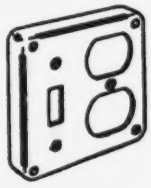
5. Two single receptacles

FIGURE 75



6. Toggle switch and duplex receptacles

FIGURE 76

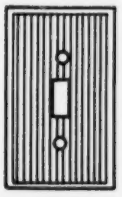


INFORMATION SHEET

D. Wall plates

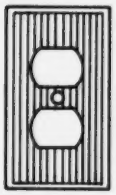
1. Single toggle switch

FIGURE 77



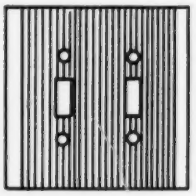
2. Duplex receptacle

FIGURE 78



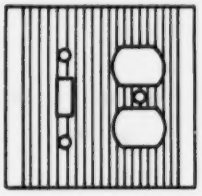
3. Two toggle switches

FIGURE 79



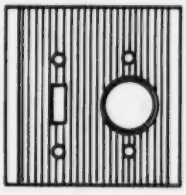
4. Single toggle duplex receptacle

FIGURE 80



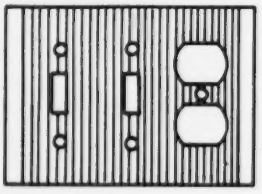
5. Single toggle and single receptacle

FIGURE 81



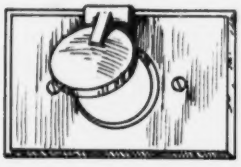
6. Two toggles and duplex receptacle

FIGURE 82



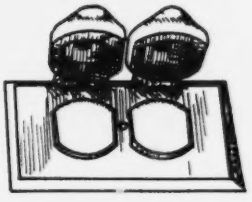
7. Weatherproof single receptacle

FIGURE 83



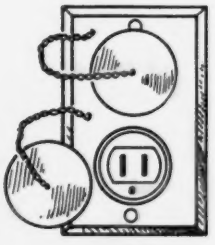
8. Weatherproof duplex receptacle (horizontal)

FIGURE 84



9. Weatherproof duplex receptacle with screw covers

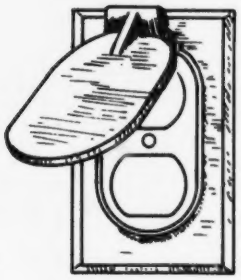
FIGURE 85



INFORMATION SHEET

10. Weatherproof duplex receptacle (vertical)

FIGURE 86



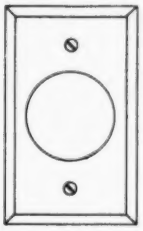
E. Handy box covers

1. Blank

FIGURE 87

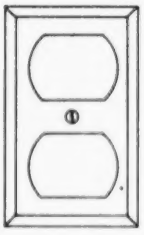
2. Single receptacle

FIGURE 88



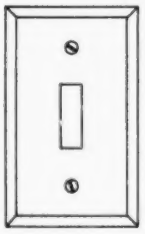
3. Duplex receptacle

FIGURE 89



4. Single toggle

FIGURE 90



INFORMATION SHEET

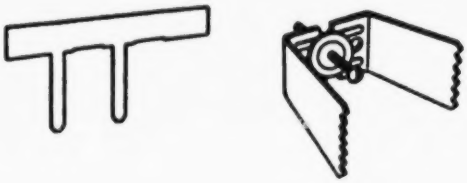
X. Common supports and anchors

A. Bar hanger

FIGURE 91

B. Switch box supports

FIGURE 92



C. One hole strap

FIGURE 93

D. Two hole strap

FIGURE 94

E. Plastic anchors

FIGURE 95

Flange Plug

F. Lead anchor

FIGURE 96

G. Lag screw shield

FIGURE 97

H. Expansion bolt

FIGURE 98

INFORMATION SHEET

I. Toggle bolt

FIGURE 99

J. Molley bolt anchor

FIGURE 100

K. Drive pin

FIGURE 101

L. Drive stud

FIGURE 102

XI. Common screws, bolts, nuts, and nails

A. Screws

1. Sheet metal screw

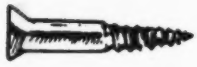
FIGURE 103

2. Self-drilling screw

FIGURE 104

3. Flat head wood screw

FIGURE 105



INFORMATION SHEET

4. Machine screw

FIGURE 106

5. Set screw

FIGURE 107

B. Bolts

1. Carriage bolt

FIGURE 108

2. Hex head bolt

FIGURE 109

3. Hex socket head bolt

FIGURE 110

C. Nuts

1. Acorn nuts

FIGURE 111

2. Spring nut

FIGURE 112

3. Wing nut

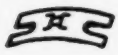
FIGURE 113

4. Fixture nut

FIGURE 114

5. Single thread nut

FIGURE 115



6. Hex nut

FIGURE 116

INFORMATION SHEET

D. Nails

1. Box or common

(NOTE: Common nails have gripping creases on the shank under the head and are slightly larger in diameter than box nails.)

FIGURE 117

8d

16d

2. Masonry nail

FIGURE 118

3. Galvanized roofing nail

FIGURE 119

4. Staples

FIGURE 120

INFORMATION SHEET

XII. Common connectors, terminals, and lugs

A. Connectors

1. Crimp sleeve

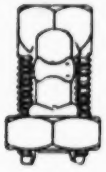
FIGURE 121

2. Set screw

FIGURE 122

3. Split bolt

FIGURE 123



4. Service entrance

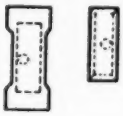
FIGURE 124

5. Wire nuts

FIGURE 125

6. Crimp-type butt connectors

FIGURE 126



INFORMATION SHEET

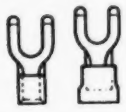
B. Terminals

1. Ring

FIGURE 127

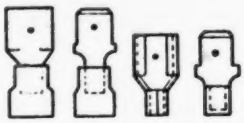
2. Spade

FIGURE 128



3. Quick disconnect

FIGURE 129



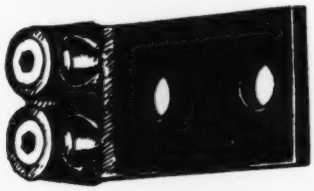
C. Lugs

1. Single terminal lug

FIGURE 130

2. Twin terminal lug

FIGURE 131



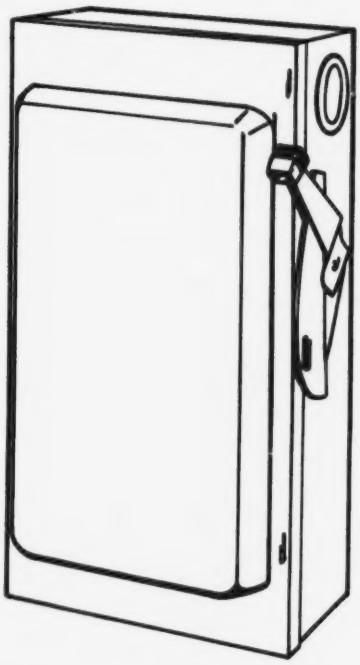
INFORMATION SHEET

XIII. Types of safety switch enclosures

(NOTE: This can be either a general duty or H. P. rated switch.)

A. Indoor (NEMA Type 1)

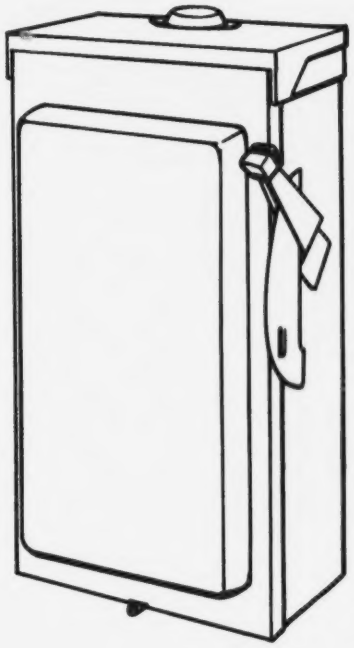
FIGURE 132



INFORMATION SHEET

B. Raintight (NEMA Type 3R)

FIGURE 133



(NOTE: These switches can be fusible or nonfusible, depending on need. Either type will serve as the disconnect for an air conditioning system condenser.)

XIV. Common load center accessories

A. Grounding or grounded bar

FIGURE 134

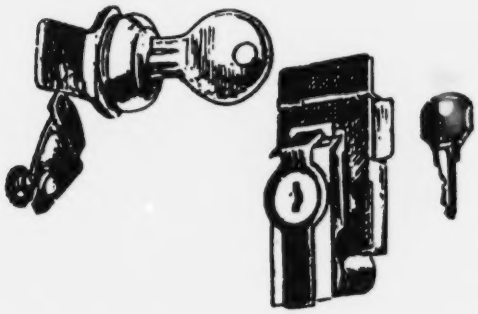
B. Lug

FIGURE 135

INFORMATION SHEET

C. Flush lock assembly

FIGURE 136



D. Closure plate

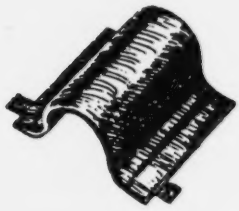
FIGURE 137

E. Padlock attachment

FIGURE 138

F. Lock off for breakers

FIGURE 139

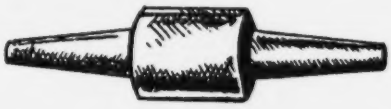


G. Conduit hub for rainproof enclosure

FIGURE 140

H. Handle tie

FIGURE 141



(NOTE: The tie is used to cause simultaneous mechanical tripping between two breakers.)

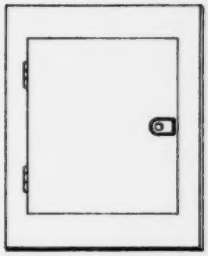
INFORMATION SHEET

XV. Installations for load centers

(NOTE: These are all possible places for the installation of service equipment for both new construction and remodel work. A new exterior mounted panel is often used to feed an existing panel as a sub-panel to provide more circuits in a remodel.)

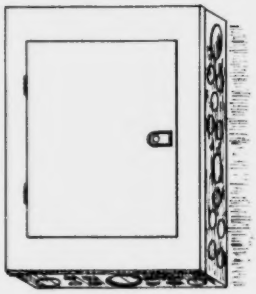
A. Flush interior

FIGURE 142



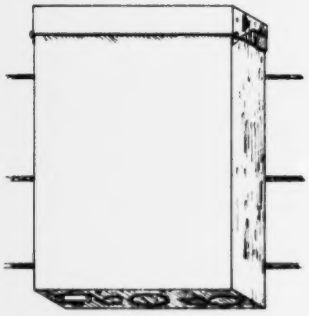
B. Surface interior

FIGURE 143



C. Surface exterior

FIGURE 144

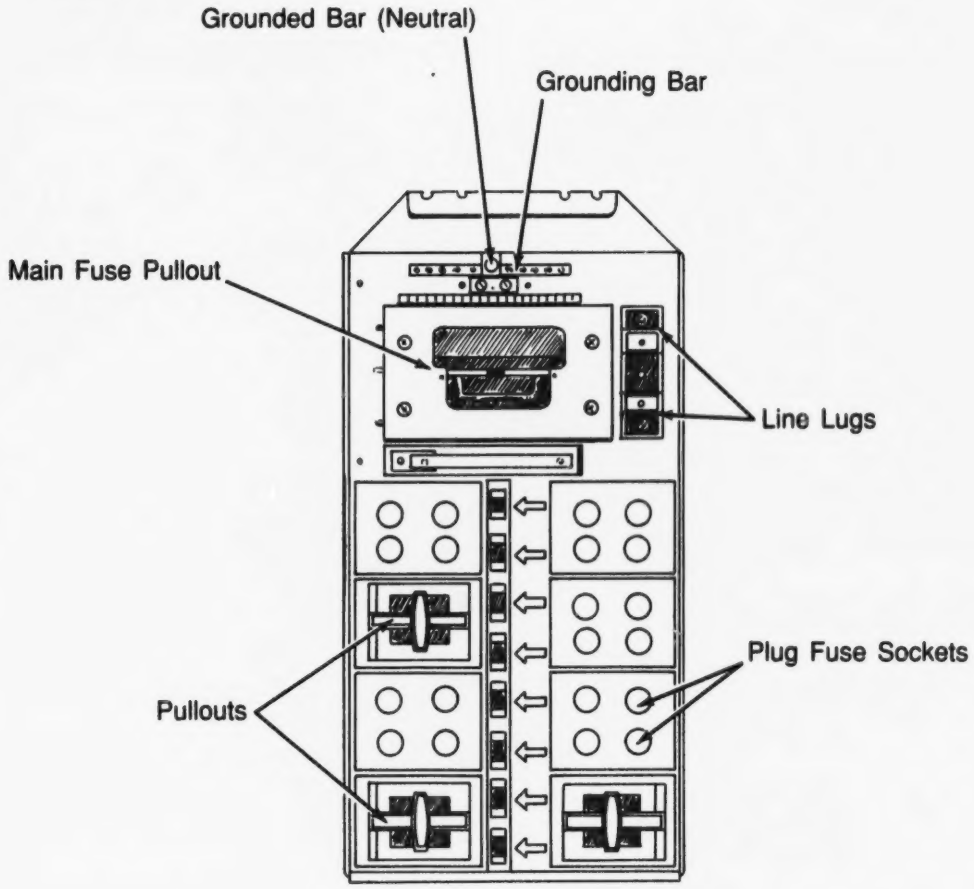


(NOTE: These enclosures are usually NEMA Type 3R breaker assemblies.)

INFORMATION SHEET

XVI. Parts of a fusible load center

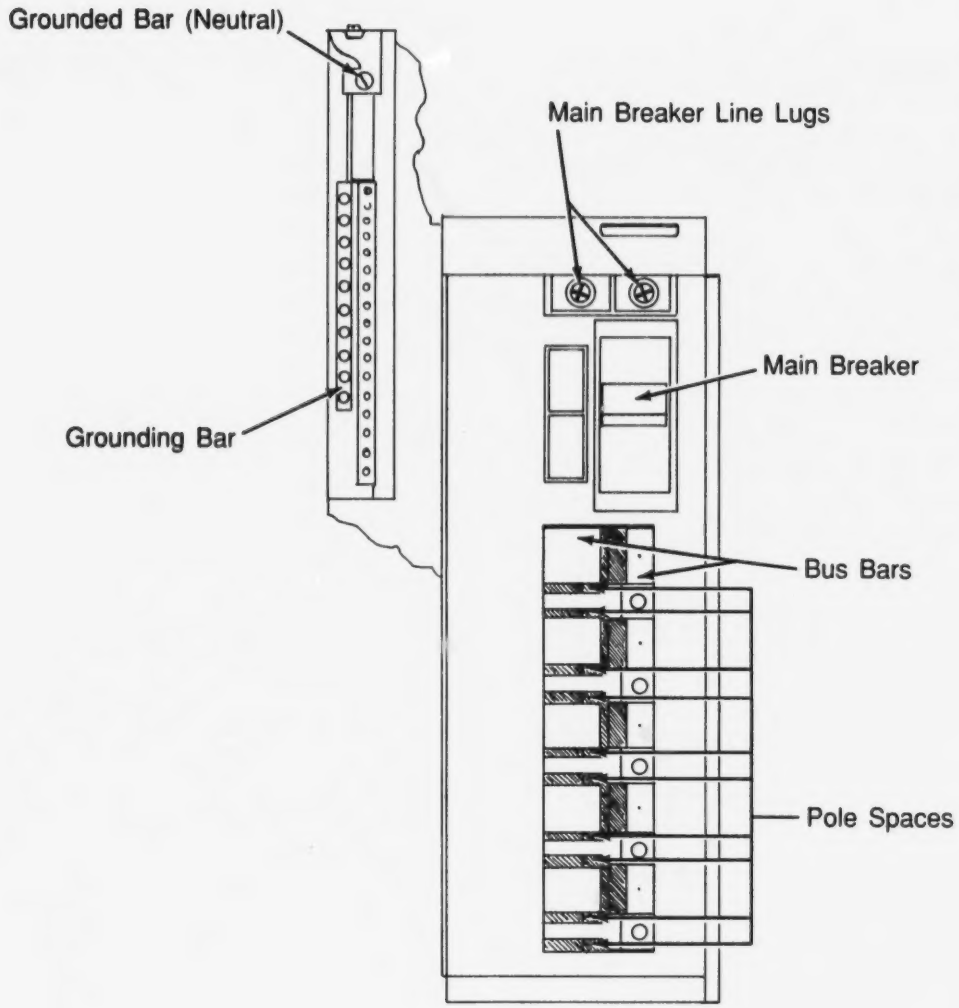
FIGURE 145



INFORMATION SHEET

XVII. Parts of a breaker load center

FIGURE 146



ELECTRICAL MATERIALS
UNIT I

JOB SHEET #1 — INSTALL A SET SCREW CONDUIT FITTING

I. Tools and equipment

A. 1/2" set screw fitting

(NOTE: For this job sheet either a connector or coupling is suitable.)

B. 1/2" conduit

C. Screwdriver

D. Safety glasses

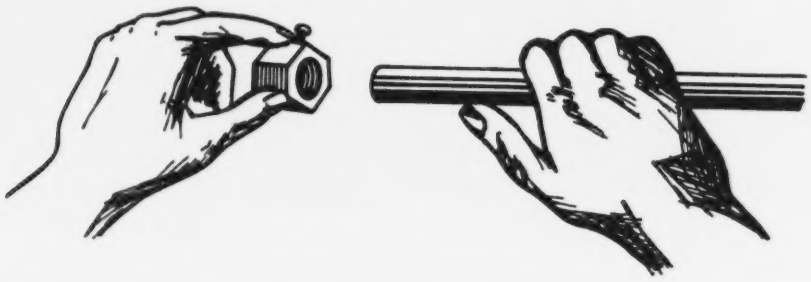
II. Procedure

(NOTE: Conduit should be reamed and should have a square cut end.)

A. Put on safety glasses

B. Slide the connector onto the conduit until it bottoms (Figure 147)

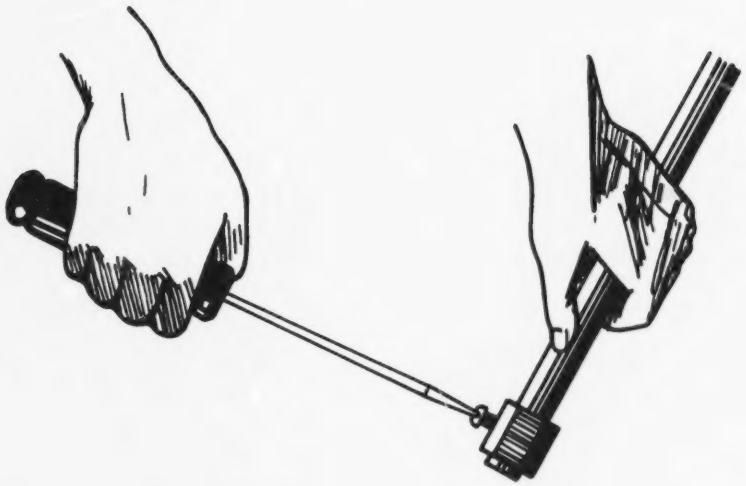
FIGURE 147



JOB SHEET #1

C. Secure screw with screwdriver (Figure 148)

FIGURE 148



CAUTION
Keep hand holding conduit in position away from the connector to avoid getting jabbed if the screwdriver should slip. Don't overtighten set screw.

ELECTRICAL MATERIALS
UNIT I

JOB SHEET #2 — INSTALL A LIQUID TIGHT CONDUIT FITTING

I. Tools and equipment

A. 1/2" compression type fitting

(NOTE: For the purpose of this job sheet either a connector or coupling may be used.)

B. 1/2" conduit

C. 2 pairs groove joint pliers

(NOTE: Two adjustable wrenches or one wrench and one pair of pliers will also suffice.)

D. Safety glasses

II. Procedure

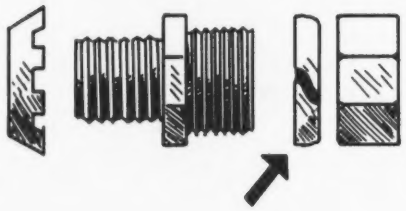
(NOTE: The conduit should be reamed and should have straight even ends.)

A. Put on safety glasses

B. Loosen compression nut

(NOTE: Don't completely remove nut. Look inside and be sure compression ring is inside the fitting. See Figure 149.)

FIGURE 149

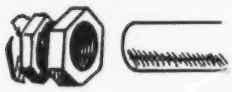


JOB SHEET #2

C. Slide fitting onto conduit (Figure 150)

(NOTE: The conduit should make a click that will also be felt when it bottoms.)

FIGURE 150



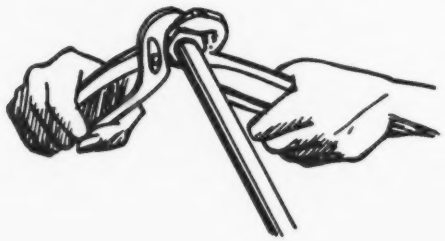
D. Tighten compression nut by hand (Figure 151)

FIGURE 151

E. Tighten fitting with pliers or adjustable wrenches (Figure 152)

CAUTION
Overtightening the smaller trade size fittings can cause threads to strip or nuts to crack.

FIGURE 152



ELECTRICAL MATERIALS
UNIT I

JOB SHEET #3 — BRAID THE NEUTRAL CONDUCTOR OF A SERVICE ENTRANCE CABLE

I. Tools and equipment

A. SE cable

B. Knife

C. Safety glasses

D. Lineman's pliers

II. Procedure

A. Put on safety glasses

B. Strip off a length of the outer sheath

(NOTE: Always use safe working practices when using a knife.)

C. Separate the neutral stands into two separate groups (Figure 153)

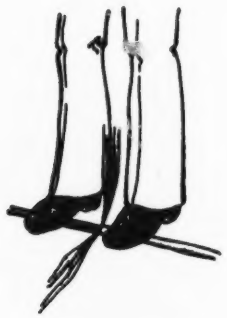
FIGURE 153

JOB SHEET #3

D. Stand on the cable (Figure 154)

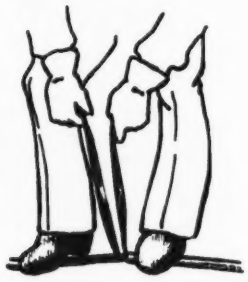
(NOTE: Be sure the conductors are not on rocks or other materials that could damage the insulation while you have them secured.)

FIGURE 154



E. Bend over and grasp the separated neutral (Figure 155)

FIGURE 155



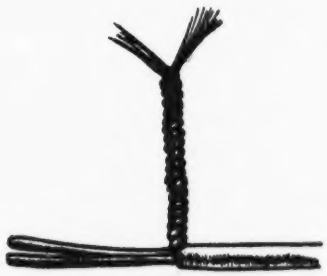
JOB SHEET #3

F. Twist the conductor together while pulling upward (Figure 156)

FIGURE 156

G. Braid as far as possible by hand (Figure 157)

FIGURE 157



JOB SHEET #3

H. Twist with pliers until braid is continuous and uniform (Figure 158)

FIGURE 158

I. Have instructor evaluate work

ELECTRICAL MATERIALS
UNIT I

TEST

NAME_____ SCORE _____

1. Match terms associated with electrical materials to their correct definitions. Write the correct numbers in the blanks. Definitions are continued on the following page.

_____a. Identification accepted by the trade in referring to a particular type of insulation.

_____b. One thousandth of an inch

_____c. The diameter of a conductor in thousandths of inches multiplied times itself

_____d. Wiring system of less than 50 volts originating at a transformer

_____e. Electrical device used to step up or step down a primary voltage to a desired secondary voltage

_____f. System designed for surface installations

_____g. Electrical equipment that carries or transfers current but does not use it

_____h. Organization responsible for the setting of specifications for the various classes of enclosures

_____i. General-purpose enclosure for indoor use under usual service conditions

_____j. Common residential outdoor enclosure

_____k. Two or more conductors grouped together in an overall covering

_____l. Material which permits the free flow of electrons

1. Low-voltage system
2. NEMA Type 1
3. Type letter
4. Device
5. Circular mils
6. NEMA Type 3R
7. Transformer
8. Mil
9. NEMA
10. Surface raceways
11. Circuit
12. Switch
13. Cable
14. Receptacle
15. Circuit breaker
16. Conductor

TEST

_____m. Complete path for current to flow from source through the load and back to the source

_____n. Switch that automatically interrupts an electric circuit under an infrequent abnormal condition

_____o. Device used to open or transfer circuit direction

_____p. Mounted, female electrical fitting that contains the live parts of the circuit

2. Write the conductor insulation designated by the type letters listed below.

a. R —_____

b. X —_____

c. H —_____

d. T —_____

e. N —_____

f. W—_____

3. Discuss briefly size classification of conductors.

American wire gauge (AWG)

1) _____

_____

2) _____

_____

TEST

Thousand circular Mils (MCM)

1) _____

2) _____

4. List three types of cables commonly found in construction.

a. _____

b. _____

c. _____

5. List two facts about cords and their conductors.

a. _____

_____

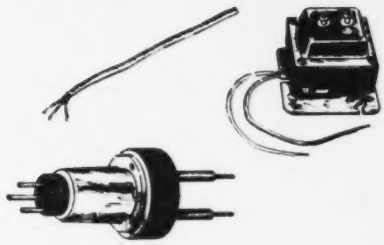
b. _____

_____

TEST

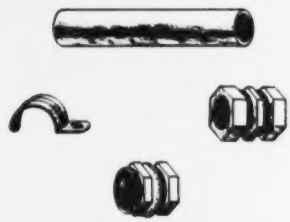
6. Identify the following wiring systems used in construction. Write their correct names in the blanks. (Question 6 is continued on the following page.)

Non-metallic sheathed cable system
Flexible metal conduit system
Surface raceway system
Liquid tight flexible metal conduit system
Electrical metallic tubing system
Polyvinyl chloride conduit system
Rigid metal conduit system
Low voltage system



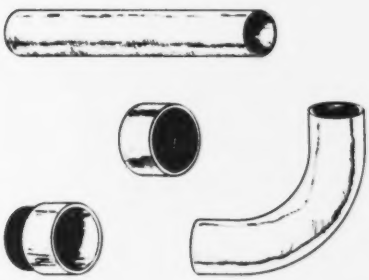
a. _____

_____



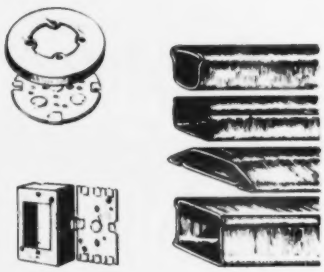
b. _____

_____



c. _____

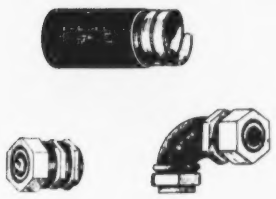
_____



d. _____

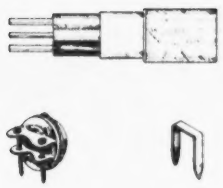
_____

TEST



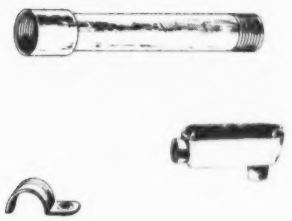
e. _____

_____



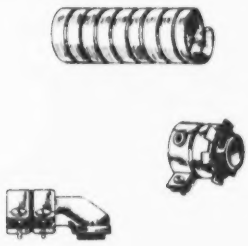
f. _____

_____



g. _____

_____



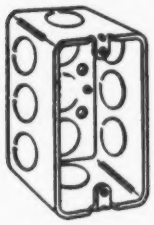
h. _____

_____

TEST

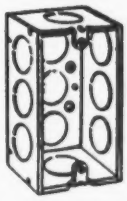
7. Identify the following boxes used in construction wiring. Write the correct names in the blanks.

Handy Boxes:
Molded construction
Welded construction
Extension
Bracket box



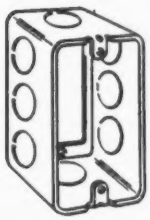
a. _____

_____



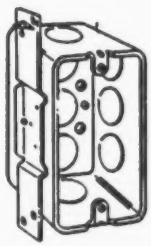
b. _____

_____



c. _____

_____



d. _____

_____

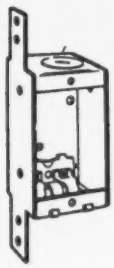
TEST

(Continued)

7. Identify the following boxes used in construction wiring. Write the correct names in the blanks.

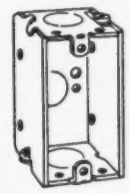
Switch Boxes:

Bracket nongangable with cable clamps
Gangable with nail holes
Gangable with ears and cable clamps
Gangable bracket box with cable clamps
With drywall grips, cable clamps, and ears
Beveled corner with cable clamps
Gangable with grounding pigtail
Nail-on type
Solid two-gang bracket



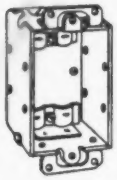
e. _____

_____



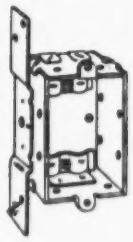
f. _____

_____



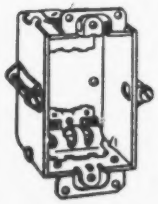
g. _____

_____



h. _____

_____



i. _____

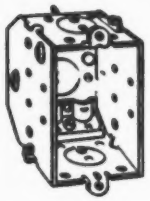
TEST

(Continued)

7. Identify the following boxes used in construction wiring. Write the correct names in the blanks.

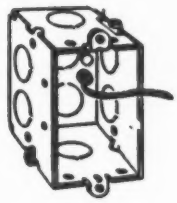
Switch Boxes:

Bracket nongangable with cable clamps
Gangable with nail holes
Gangable with ears and cable clamps
Gangable bracket box with cable clamps
With drywall grips, cable clamps, and ears
Beveled corner with cable clamps
Gangable with grounding pigtail
Nail-on type
Solid two-gang bracket



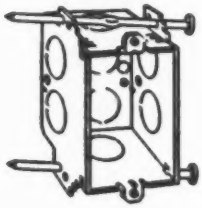
j. _____

_____



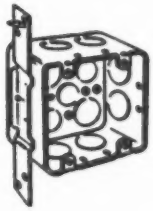
k. _____

_____



l. _____

_____



m. _____

_____

TEST

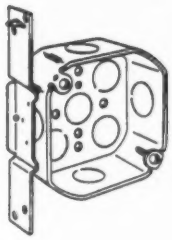
(Continued)

7. Identify the following boxes used in construction wiring. Write the correct names in the blanks.

Octagon Boxes:
With cable clamps and nail holes
With bracket
Extension
With cable clamps and grounding pigtails
With bar hanger and cable clamps

n. _____

_____



o. _____

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p. _____

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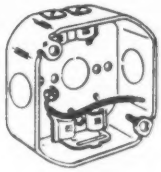

q. _____

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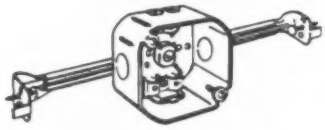


r. _____

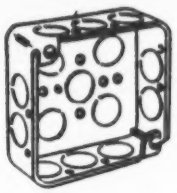
TEST

(Continued)

7. Identify the following boxes used in construction wiring. Write the correct names in the blanks.

Square Boxes:

Molded construction
Welded construction
With bracket
With bracket, cable clamps, and grounding pigtail
Square box extension



s. _____

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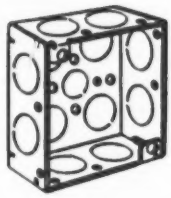

t. _____

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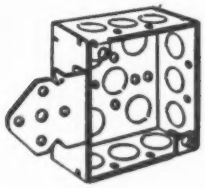
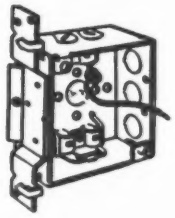


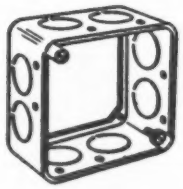
u. _____

_____



v. _____

_____



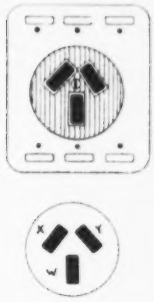
w. _____

TEST

8. Identify the following devices commonly used in construction wiring. Write the correct names in the blanks. (Question 8 is continued on the following pages.)

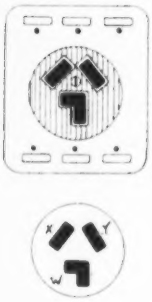
Receptacles:

Range receptacle 125/250V; 50 amp
Dryer receptacle 125/250V; 30 amp
Air conditioning receptacle 250V; 30 amp
Air conditioning receptacle 250V; 20 amp
Duplex grounding receptacle 125V; 15 amp
Dual voltage receptacle 125/250V; 20 amp



a. _____

_____



b. _____

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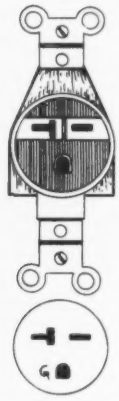


c. _____

TEST

(Continued)

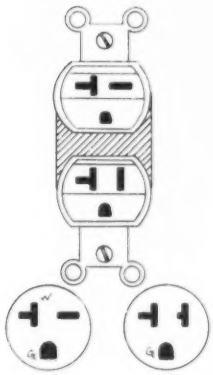
8. Identify the following devices commonly used in construction wiring. Write the correct names in the blanks.

Receptacles:

Range receptacle 125/250V; 50 amp
Dryer receptacle 125/250V; 30 amp
Air conditioning receptacle 250V; 30 amp
Air conditioning receptacle 250V; 20 amp
Duplex grounding receptacle 125V; 15 amp
Dual voltage receptacle 125/250V; 20 amp

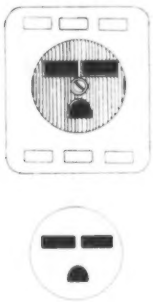
d. _____

_____



e. _____

_____



f. _____

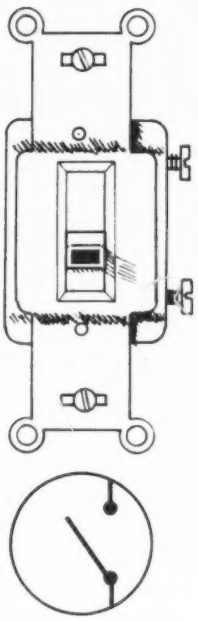
TEST

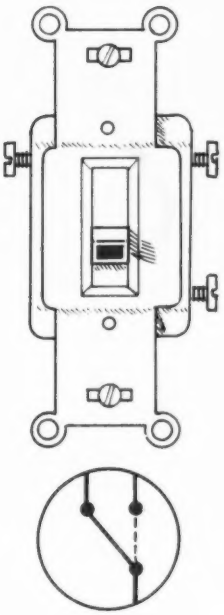
(Continued)

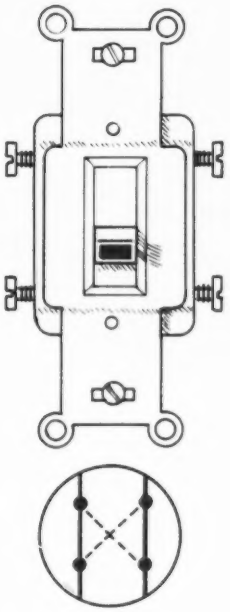
8. Identify the following devices commonly used in construction wiring. Write the correct names in the blanks.

Switches:

Single pole
Three way
Four way
Double pole
Dimmer
Low voltage push button







g. _____ h. _____ i. _____

_____ _____ _____

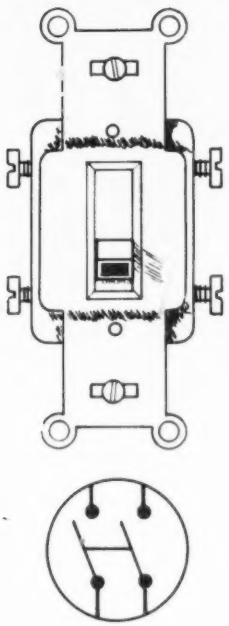
TEST

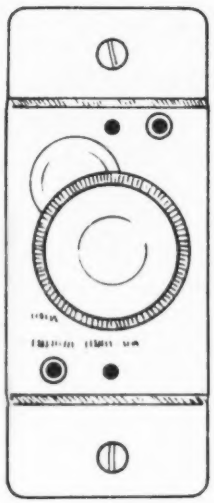
(Continued)

8. Identify the following devices commonly used in construction wiring. Write the correct names in the blanks.

Switches:

Single pole
Three way
Four way
Double pole
Dimmer
Low voltage push button





j. _____ k. _____ l. _____

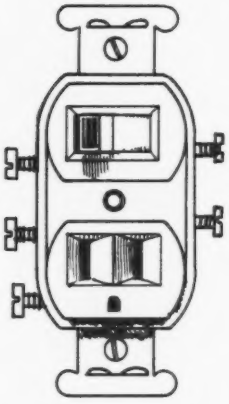
_____ _____ _____

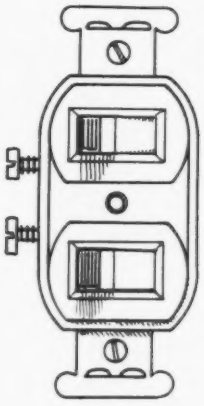
TEST

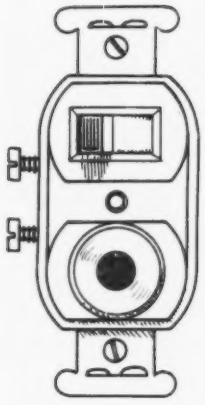
(Continued)

8. Identify the following devices commonly used in construction wiring. Write the correct names in the blanks.

Combination Devices:
Switch and receptacle
Two switches
Switch and pilot light







m. _____ n. _____ o. _____

_____ _____ _____

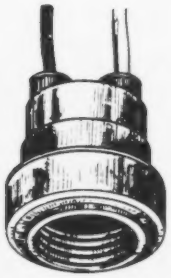
TEST

(Continued)

8. Identify the following devices commonly used in construction wiring. Write the correct names in the blanks.

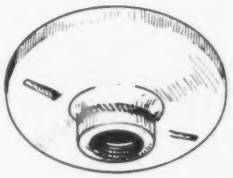
Sockets:

Keyless pigtail
Keyless cover
Pull chain cover
Pull chain cover with grounding type receptacle



p. _____

_____

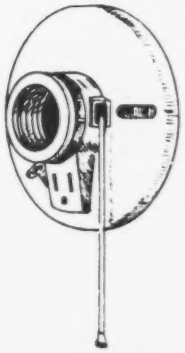


q. _____

_____

r. _____

_____



s. _____

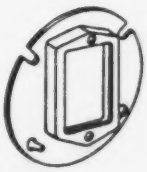
_____

TEST

9. Identify the following covers and plates used in construction wiring. Write the correct names in the blanks.

Round Covers:

Flat blank
Flat with knockout
Raised with knockout
Raised for single device
Raised open
Flat toggle
Flat duplex
Flat single receptacle



a. _____ b. _____ c. _____ d. _____

_____ _____ _____ _____

e. _____ f. _____ g. _____ h. _____

_____ _____ _____ _____

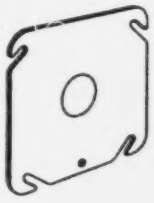
TEST

(Continued)

9. Identify the following covers and plates used in construction wiring. Write the correct names in the blanks.

Square Covers:
Flat blank
Flat blank with knockout
Raised open
Flat single device
Raised single device
Flat two devices
Raised two devices

i. _____

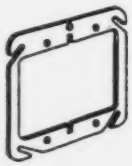


j. _____

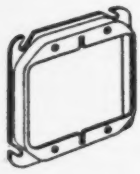
k. _____

l. _____

m. _____



n. _____



o. _____

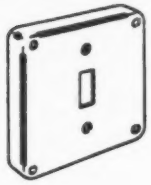
TEST

(Continued)

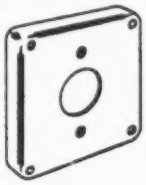
9. Identify the following covers and plates used in construction wiring. Write the correct names in the blanks.

Exposed Work Raised Square Covers:

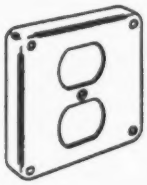
Single toggle switch
Single receptacle
Duplex receptacle
Two toggle switches
Two single receptacles
Toggle switch and duplex receptacle



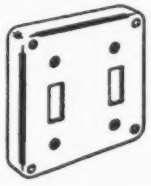
p. _____



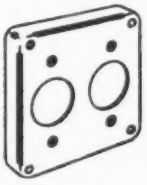
q. _____



r. _____



s. _____



t. _____

u. _____

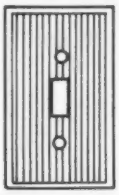
TEST

(Continued)

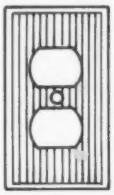
9. Identify the following covers and plates used in construction wiring. Write the correct names in the blanks.

Wall Plates:

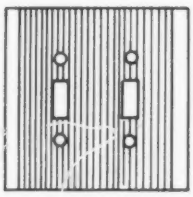
Single toggle switch
Duplex receptacle
Two toggle switches
Single toggle and duplex receptacle
Single toggle and single receptacle
Two toggles and duplex receptacle
Weatherproof single receptacle
Weatherproof duplex receptacle horizontal
Weatherproof duplex receptacle with screw covers
Weatherproof duplex receptacle vertical



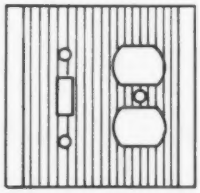
v. _____
_____



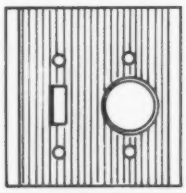
w. _____
_____



x. _____
_____



y. _____
_____



z. _____
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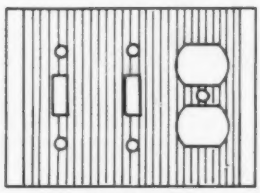


aa. _____
_____

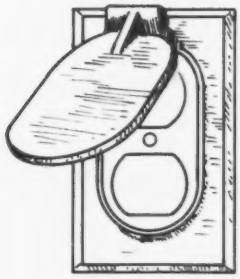
TEST

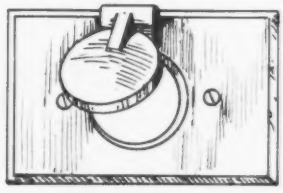
(Continued)

9. Identify the following covers and plates used in construction wiring. Write the correct names in the blanks.

Wall Plates:

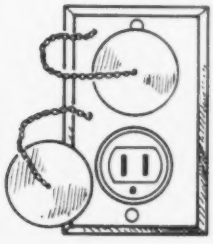
Single toggle switch
Duplex receptacle
Two toggle switches
Single toggle and duplex receptacle
Single toggle and single receptacle
Two toggles and duplex receptacle
Weatherproof single receptacle
Weatherproof duplex receptacle horizontal
Weatherproof duplex receptacle with screw covers
Weatherproof duplex receptacle vertical

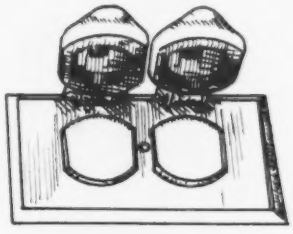




bb. _____ cc. _____

_____ _____





dd. _____ ee. _____

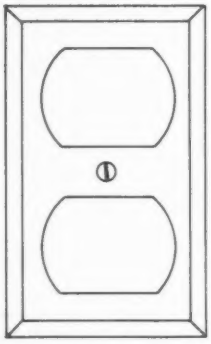
_____ _____

TEST

(Continued)

9. Identify the following covers and plates used in construction wiring. Write the correct names in the blanks.

Handy Box Covers:
Blank
Single receptacle
Single toggle
Duplex receptacle

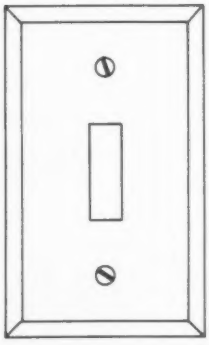


ff. _____

_____

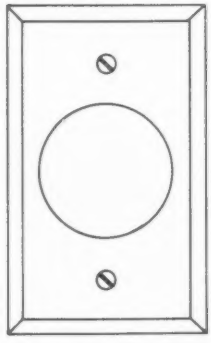
gg. _____

_____



hh. _____

_____



ii. _____

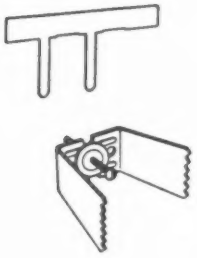
_____

TEST

10. Identify the following common supports and anchors. Write the correct names in the blanks.

Bar hanger	**Switch box supports**	**One hole strap**	**Lag screw shield**
Lead anchor	**Plastic anchors**	**Two hole strap**	**Expansion bolt**
Toggle bolt	**Drive pin**	**Drive stud**	**Molley bolt anchor**

a. _____



b. _____

c. _____

d. _____

e. _____

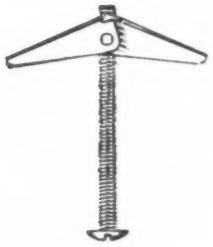
f. _____

TEST

(Continued)

10. Identify the following common supports and anchors. Write the correct names in the blanks.

Bar hanger	**Switch box supports**	**One hole strap**	**Lag screw shield**
Lead anchor	**Plastic anchors**	**Two hole strap**	**Expansion bolt**
Toggle bolt	**Drive pin**	**Drive stud**	**Molley bolt anchor**



g. _____ h. _____ i. _____

j. _____ k. _____ l. _____

TEST

11. Identify the following common screws, bolts, nuts and nails. Write the correct names in the blanks.

Screws
- **Sheet metal**
- **Set**
- **Self-drilling**
- **Machine**
- **Flat head wood**

Bolts
- **Hex socket head**
- **Hex head**
- **Carriage**

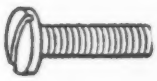
Nuts
- **Acorn**
- **Spring**
- **Wing**
- **Fixture**
- **Single thread**
- **Hex**

Nails
- **Galvanized roofing**
- **Box or common**
- **Masonry**
- **Staple**

a. _____

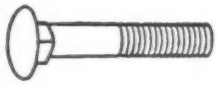
b. _____

c. _____



d. _____

e. _____



f. _____

TEST

(Continued)

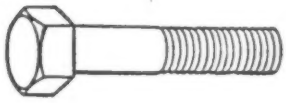
11. Identify the following common screws, bolts, nuts and nails. Write the correct names in the blanks.

Screws
- **Sheet metal**
- **Set**
- **Self-drilling**
- **Machine**
- **Flat head wood**

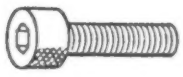
Bolts
- **Hex socket head**
- **Hex head**
- **Carriage**

Nuts
- **Acorn**
- **Spring**
- **Wing**
- **Fixture**
- **Single thread**
- **Hex**

Nails
- **Galvanized roofing**
- **Box or common**
- **Masonry**
- **Staple**



g. _____



h. _____

i. _____

j. _____

k. _____

l. _____

TEST

(Continued)

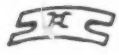
11. Identify the following common screws, bolts, nuts and nails. Write the correct names in the blanks.

Screws
- **Sheet metal**
- **Set**
- **Self-drilling**
- **Machine**
- **Flat head wood**

Bolts
- **Hex socket head**
- **Hex head**
- **Carriage**

Nuts
- **Acorn**
- **Spring**
- **Wing**
- **Fixture**
- **Single thread**
- **Hex**

Nails
- **Galvanized roofing**
- **Box or common**
- **Masonry**
- **Staple**



m. _____ n. _____ o. _____

p. _____ q. _____ r. _____

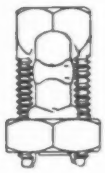
TEST

12. Identify the following common connectors, terminals and lugs. Write the correct names in the blanks.

Connectors	Terminals	Lugs
Crimp-type butt	Quick disconnect	Single terminal lug
Service entrance	Ring terminal	Twin terminal lug
Wire nuts	Spade terminal	
Crimp sleeve		
Set screw		
Split bolt		

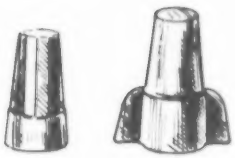
a. _____

b. _____

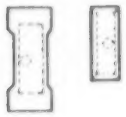


c. _____

d. _____



e. _____



f. _____

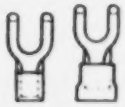
TEST

(Continued)

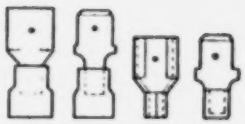
12. Identify the following common connectors, terminals and lugs. Write the correct names in the blanks.

Connectors	Terminals	Lugs
Crimp-type butt	**Quick disconnect**	**Single terminal lug**
Service entrance	**Ring terminal**	**Twin terminal lug**
Wire nuts	**Spade terminal**	
Crimp sleeve		
Set screw		
Split bolt		

g. _____



h. _____



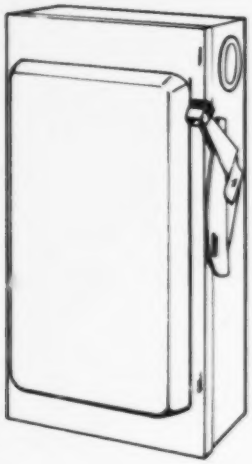
i. _____

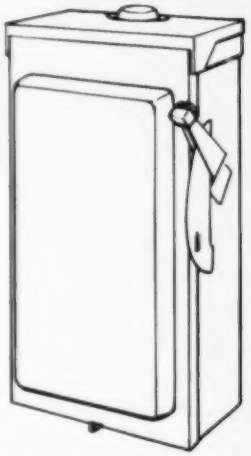
j. _____

k. _____

TEST

13. Label the following types of safety switch enclosures. Write the correct names in the blanks.



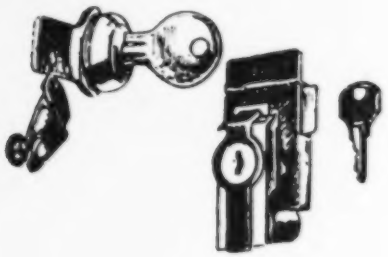


a. _____ b. _____

14. Identify the following common load center accessories. Write the correct names in the blanks.

Flush lock assembly
Padlock attachment
Conduit hub for rainproof enclosure
Handle tie

Lock off for breakers
Closure plate
Grounding or grounded bar
Lug



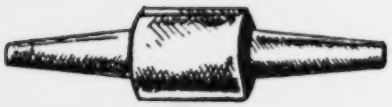
a. _____ b. _____

TEST

(Continued)

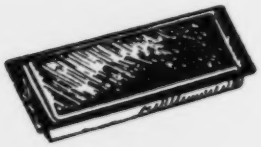
14. Identify the following common load center accessories. Write the correct names in the blanks.

Flush lock assembly
Padlock attachment
Conduit hub for rainproof enclosure
Handle tie
Lock off for breakers
Closure plate
Grounding or grounded bar
Lug



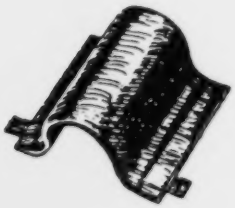
c. _____

d. _____



e. _____

f. _____



g. _____

h. _____

TEST

15. List three possible installations for load centers.

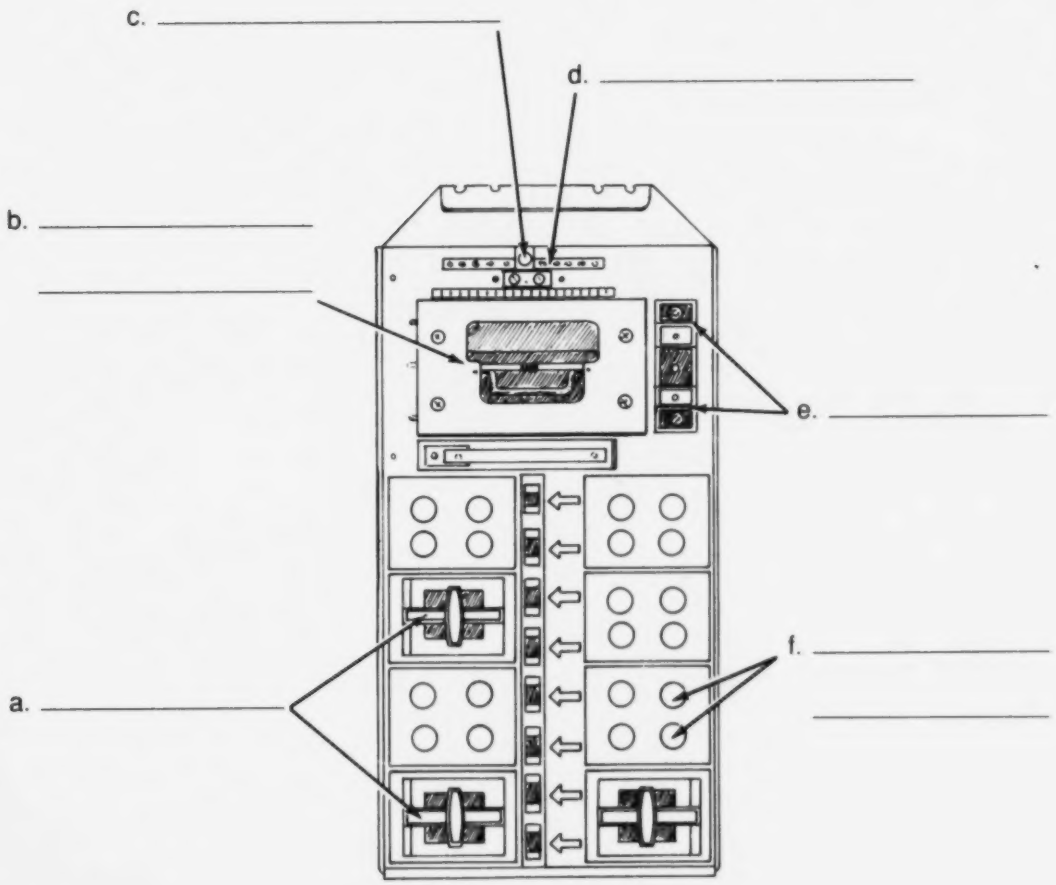
    a. _____

    b. _____

    c. _____

16. Identify parts of a fusible load center. Write the correct names in the blanks.

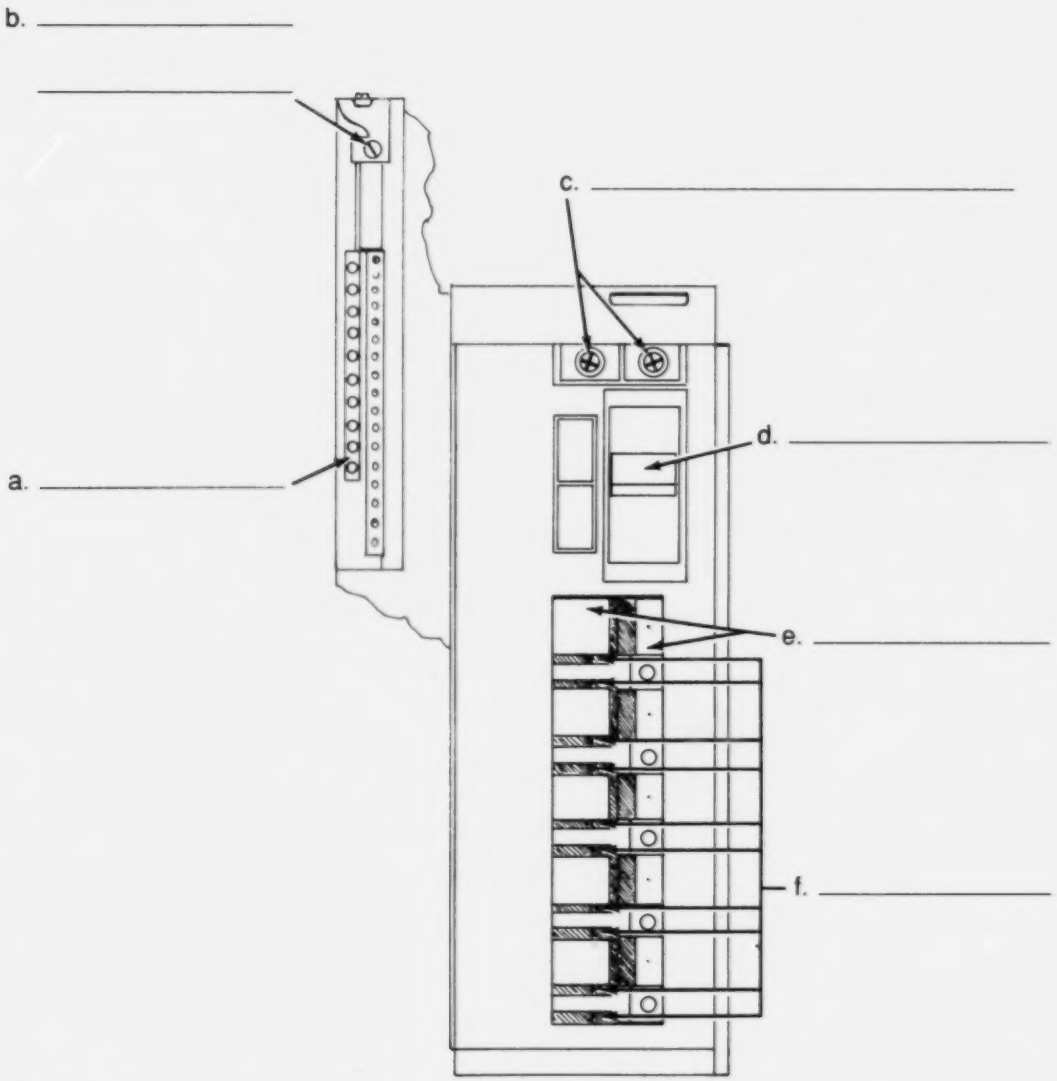
Grounded bar (Neutral)	**Plug fuse sockets**	**Main fuse pullout**
Grounding bar	**Line lugs**	**Pullouts**



TEST

17. Identify parts of a breaker load center. Write the correct names in the blanks.

Grounding bar (Neutral)	**Main breaker**	**Grounding bar**
Main breaker line lugs	**Bus bars**	**Pole spaces**



TEST

(NOTE: Test question 18 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

18. Demonstrate the ability to

    a. Install a set screw conduit fitting

    b. Install a liquid tight conduit fitting

    c. Braid the neutral conductor of a service entrance cable

ELECTRICAL MATERIALS
UNIT I

ANSWERS TO TEST

1.

a.	3	d.	1	g.	4	j.	6	m.	11	p.	14
b.	8	e.	7	h.	9	k.	13	n.	15		
c.	5	f.	10	i.	2	l.	16	o.	12		

2. a. Rubber
   b. Cross-linked polymer
   c. Heat resistant
   d. Thermoplastic
   e. Nylon jacket
   f. Moisture resistant

3. Discussion should include:

   a. American wire gauge (AWG)
      1) AWG is standard size classification in the United States for copper and aluminum wires used in electrical construction
      2) AWG gets up to 0000

   b. Thousand circular mils (MCM)
      1) MCM is the standard size classification for conductors larger than 0000
      2) MCM classifications go up to 2,000 MCM

4. Answer should include any three of the following

   a. Nonmetallic sheathed cable (NM)
   b. Service-entrance cable (SE)
   c. Low-voltage cable
   d. Underground cable (UF)
   e. Underground service-entrance cable (USE)

5. Answer should include any two of the following

   a. Cords used in a grounded system must have an identified grounded conductor

   b. Cords which have a conductor with green or green with yellow striped insulation shall use that conductor for grounding purposes only

ANSWERS TO TEST

c. Ungrounded conductors can be any color other than those designated for grounded or grounding conductors

d. Cords should be used within their amp and insulation rating or classification

6. a. Low voltage system
   b. Electrical metallic tubing system
   c. Polyvinyl chloride conduit system
   d. Surface raceway system
   e. Liquid tight flexible metal conduit system
   f. Non-metallic sheathed cable system
   g. Rigid metal conduit system
   h. Flexible metal conduit system

7. Handy boxes
   a. Molded construction
   b. Welded construction
   b. Extension
   d. Bracket box

   Switch boxes
   e. Bracket nongangable with cable clamps
   f. Gangable with nail holes
   g. Gangable with ears and cable clamps
   h. Gangable bracket box with cable clamps
   i. With drywall grips, cable clamps and ears
   j. Beveled corner with cable clamps
   k. Gangable with grounding pigtail
   l. Nail on type
   m. Solid two-gang bracket

   Octagon boxes
   n. With cable clamps and nail holes
   o. With bracket
   p. Extension
   q. With cable clamps and grounding pigtail
   r. With bar hanger and cable clamps

   Square boxes
   s. Molded construction
   t. Welded construction
   u. With bracket
   v. With bracket, cable clamps and grounding pigtail
   w. Square box extension

ANSWERS TO TEST

8. Receptacles
   - a. Range receptacle 125/250V; 50 amp
   - b. Dryer receptacle 125/250V; 30 amp
   - c. Air conditioning receptacle 250V; 20 amp
   - d. Duplex grounding receptacle 125V; 15 amp
   - e. Dual voltage receptacle 125/250V; 20 amp
   - f. Air conditioning receptacle 250V; 30 amp

   Switches
   - g. Single pole
   - h. Three way
   - i. Four way
   - j. Double pole
   - k. Dimmer
   - l. Low voltage push button

   Combination devices
   - m. Switch and receptacle
   - n. Two switches
   - o. Switch and pilot light

   Sockets
   - p. Keyless pigtail
   - q. Keyless cover
   - r. Pull chain cover
   - s. Pull chain cover with grounding type receptacle

9. Round covers
   - a. Flat blank
   - b. Flat with knockout
   - c. Raised with knockout
   - d. Raised for single device
   - e. Raised open
   - f. Flat toggle
   - g. Flat duplex
   - h. Flat single receptacle

   Square covers
   - i. Flat blank
   - j. Flat blank with knockout
   - k. Raised open
   - l. Flat single device
   - m. Raised single device
   - n. Flat two devices
   - o. Raised two devices

   Exposed work raised square covers
   - p. Single toggle switch
   - q. Single receptacle
   - r. Duplex receptacle
   - s. Two toggle switches
   - t. Two single receptacles
   - u. Toggle switch and duplex receptacle

ANSWERS TO TEST

Wall plates

- v. Single toggle switch
- w. Duplex receptacle
- x. Two toggle switches
- y. Single toggle and duplex receptacle
- z. Single toggle and single receptacle
- aa. Two toggles and duplex receptacle
- bb. Weatherproof duplex receptacle vertical
- cc. Weatherproof single receptacle
- dd. Weatherproof duplex receptacle with screw covers
- ee. Weatherproof duplex receptacle horizontal

Handy box covers

- ff. Duplex receptacle
- gg. Blank
- hh. Single toggle
- ii. Single receptacle

10.
- a. Bar hanger
- b. Switch box supports
- c. One hole strap
- d. Two hole strap
- e. Plastic anchors
- f. Lead anchor
- g. Toggle bolt
- h. Drive pin
- i. Molley bolt anchor
- j. Drive stud
- k. Expansion bolt
- l. Lag screw shield

11.
- a. Sheet metal
- b. Self-drilling
- c. Flat head wood
- d. Machine
- e. Set screw
- f. Carriage
- g. Hex head
- h. Hex socket head
- i. Acorn
- j. Spring
- k. Wing
- l. Fixture
- m. Single thread
- n. Hex
- o. Box or common
- p. Masonry
- q. Galvanized roofing
- r. Staple

12.
- a. Crimp sleeve
- b. Set screw
- c. Split bolt
- d. Service entrance
- e. Wire nuts
- f. Crimp-type butt connectors
- g. Ring terminal
- h. Spade terminal
- i. Quick disconnect
- j. Twin terminal lug
- k. Single terminal lug

13.
- a. Indoor (NEMA Type 1)
- b. Raintight (NEMA Type 3R)

14.
- a. Flush lock assembly
- b. Padlock attachment
- c. Handle tie
- d. Conduit hub for rainproof enclosure
- e. Closure plate
- f. Grounding or grounded bar
- g. Lockoff for breakers
- h. Lug

ANSWERS TO TEST

15 Answer should include the following
a. Flush interior b. Surface interior c. Surface exterior

16. a. Pullouts
b. Main fuse pullout
c. Grounded bar (Neutral)
d. Grounding bar
e. Line lugs
f. Plug fuse sockets

17. a. Grounding bar
b. Grounded bar (Neutral)
c. Main breaker line lugs
d. Main breaker
e. Bus bars
f. Pole spaces

18. Performance skills evaluated to the satisfaction of the instructor.

ELECTRICAL TOOLS
UNIT II

UNIT OBJECTIVES

After completing this unit, the student should be able to state guidelines for care and safe use of tools, match tools to their trade uses, and list factors to consider before buying tools. The student will show this ability by completing the unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. Match terms associated with electrical tools to their correct definitions.
2. State guidelines for care and safe use of electrical tools.
3. Match types of pouch tools to their common trade uses.
4. Match types of specialty tools to their common trade uses.
5. List factors that should be considered when buying tools.
6. Demonstrate the ability to
   a. Cut cable using side cut pliers.
   b. Adjust wire strippers.
   c. Trim conductor insulation using a knife.
   d. Use a soldering gun to splice conductors.
   e. Use a knockout punch.
   f. Bend a 90-degree stub with 1/2" EMT.
   g. Cut rigid conduit with a pipe cutter.
   h. Set up and use a hacksaw.
   i. Ream rigid conduit.
   j. Use a volt ohmmeter.

ELECTRICAL TOOLS
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Supplement #1 — Electrical Tools Crossword Puzzle

D. Information sheet

E. Job sheets

1. Job Sheet #1 — Cut Cable using Sidecut Pliers
2. Job Sheet #2 — Adjust Wire Strippers
3. Job Sheet #3 — Trim Conductor Insulation using a Knife
4. Job Sheet #4 — Use a Soldering Gun to Splice Conductors
5. Job Sheet #5 — Use a Knockout Punch
6. Job Sheet #6 — Bend a 90-Degree Stub with 1/2" EMT
7. Job Sheet #7 — Cut Rigid Conduit with a Pipe Cutter
8. Job Sheet #8 — Set up and use a Hacksaw
9. Job Sheet #9 — Ream Rigid Conduit
10. Job Sheet #10 — Use a Volt Ohmmeter

F. Test

G. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

SUGGESTED ACTIVITIES

B. Obtain materials to supplement unit.

1. Tool catalogs

EXAMPLES: Klein Tools and Occupational Protective Equipment, General Catalog #129. 7200 McCormick Boulevard, Chicago, Illinois 60645.

Chown Hardware & Machinery. 1987-88 Catalog, Greenlee Catalog #47. P.O. Box 2888, 333 N.W. 16th Avenue, Portland, Oregon 97208.

(NOTE: Obtain several catalogs to display for students to review.)

2. Competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Introduce unit to students.

- Ask students to review tool catalogs; discuss pouch and specialty tools, pointing out the importance of buying good grades of tools. Explain that quality not price should be their main concern when purchasing tools.

D. Provide students with objective sheet.

E. Discuss unit and specific objectives, emphasizing the care and safe use of tools.

F. Provide students with information sheets.

G. Discuss information sheets.

1. Use Information Sheet, Section I, to discuss terms and definitions.
   - Display samples of terms when appropriate to reinforce discussion.
   - Discuss or demonstrate terms that are unfamiliar to students.
2. Use Information Sheet, Section II, to discuss guidelines for care and safe use of electrical tools.
   - Explain how good care and maintenance will preserve the tools so that they will last for many years.
   - Discuss how safe and proper use of tools will save tools and prevent accidents.
   - Have students explain details of accidents that happened when tools were used improperly.
   - Demonstrate how to clean and store tools properly.

SUGGESTED ACTIVITIES

- Demonstrate how the quality and quantity of work increases when using tools in good condition compared to using tools in poor condition.
- Explain your policy for repair and replacement of damaged tools.
- Outline your tool management system for shop and job site.
- Stress that testing instruments are expensive, precision instruments that must be handled very carefully.

3. Use Information Sheet, Sections III and IV, to discuss types of tools and their uses common to the electrical trade.
   - Display tools listed in this section of the information sheet.
   - Review information and then have students complete Supplement #1, "Electrical Tools Crossword Puzzle."
   - Discuss the proper use of these tools, and allow students to handle each of them.
   - Caution students about using tools for the job for which it was designated.
   - Demonstrate the proper use of tools and allow students to demonstrate their uses.
4. Use Information Sheet, Section V, to discuss factors to consider when buying tools.
   - Review factors listed in the information an ask students to come up with other factors that may be just as important.
   - Caution students not to buy inferior tools.

H. Give test.

I. Critique test and discuss in class.

J. Reteach and retest as necessary.

K. Complete appropriate section of competency profiles.

SUGGESTED ACTIVITIES

III. Unit references

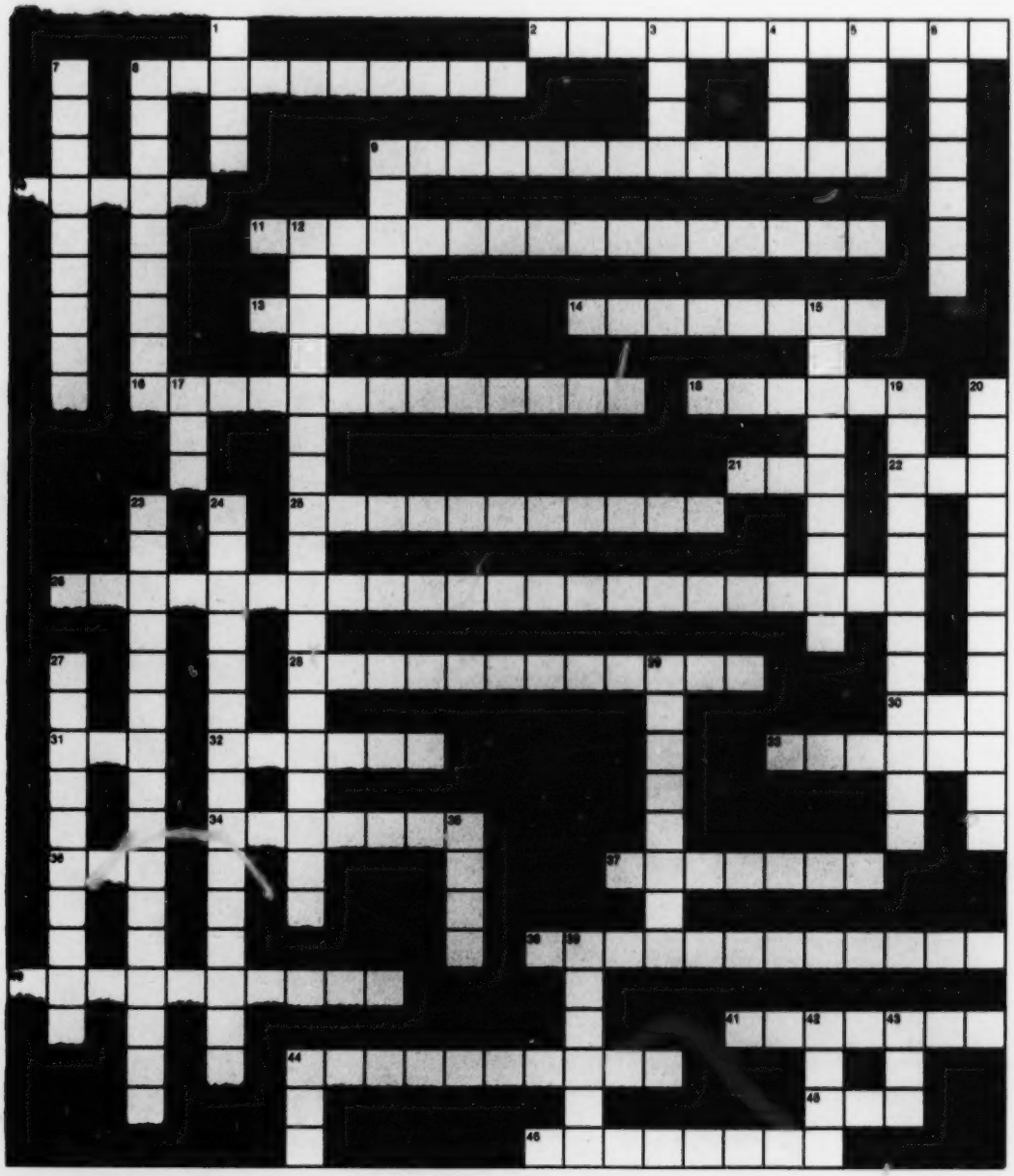
A. Taylor, Mark. *Residential Wiring*, 2d rev. ed., Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1983.

B. Taylor, Mark. *Residential Wiring*, 3d rev. ed., Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1988.

ELECTRICAL TOOLS
UNIT II

SUPPLEMENT #1 — ELECTRICAL TOOLS CROSSWORD PUZZLE

Use Information Sheet, Section I, and the clues on the following page to complete the electrical tools crossword puzzle below.



SUPPLEMENT #1

ACROSS

2. Tool used to bend heavy wall conduit. (2 words)
8. Electrical tool used to bore holes for cables, conduits, and pipe (2 words)
9. Used to cut holes for cable or conduit fittings in metal boxes, equipment, and appliances. (2 words)
10. Women's underclothing
11. Electric tool used to cut heavy lumber and to cut off pipe, lumber, and fasteners flush to surface (2 words)
13. Used to level or plumb conduit, equipment, and appliances
14. Used to hold pipe and conduit while cutting
16. Used to check for live circuits and to identify conductors (3 words)
18. Tool used to cut, form, pull, hold, and strip conductors and cables
21. Tool used to start screw holes, make pilot holes for drilling, and mark metal
22. Abbreviation of woman's name
25. Used to cut large-sized cables (2 words)
26. Used to strip insulation from conductors and to cut and form conductors (3 words)
28. Used in bit brace or drill motor to bore holes
30. Right-turn command
31. Abbreviation for an airline
32. Snack food high in energy (sometimes in shells)
33. A mark to shoot at
34. Instrument used to check amperage and motor starting and running current
36. Long, tapered rod used to shoot pool
37. Tool used to tap holes, enlarge holes, and retap damaged threads (2 words)
38. Used to remove and install screws and lugs
40. Used in a bit brace or machine to deburr pipe and conduit (2 words)

SUPPLEMENT #1

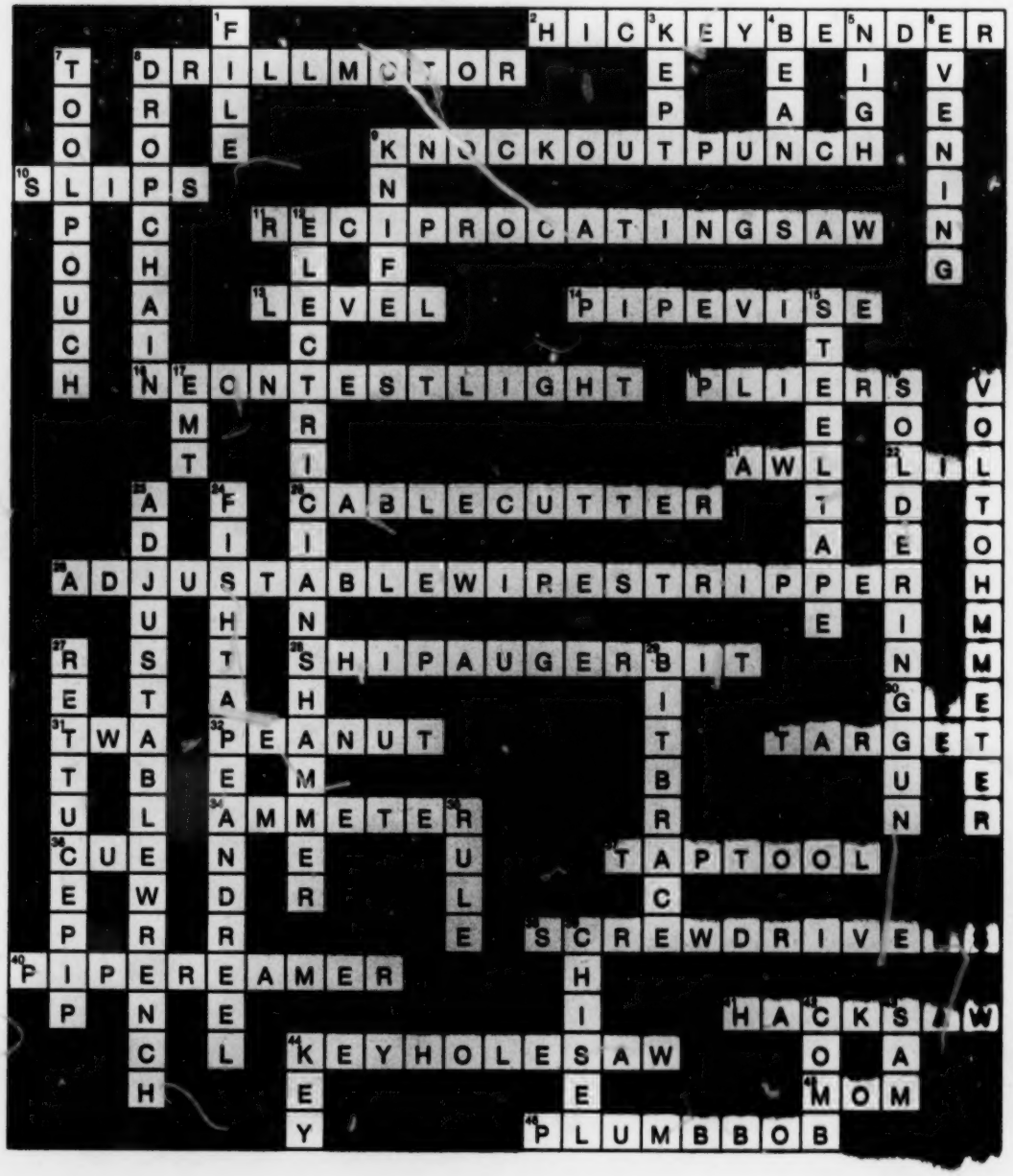
41. Used to cut pipe and conduit and to cut large conductors and cables
44. Used to cut holes in wall board and lath for box installation (2 words)
45. Short for mother
46. Used to transfer location points and to plumb conduit and equipment (2 words)

DOWN

1. Tool used to deburr conduit and sharpen tools
3. Past tense of keep
4. _____ bag; type of food
5. Close or near
6. Early part of the night
7. Used to hold, organize, and carry tools (2 words)
8. Used to pull cables in walls (2 words)
9. Used to open cartons and strip large conductors and cables
12. Used to drive and pull nails and to pry boxes loose (2 words)
15. Used to check measurements on prints, locate boxes, and determine depth and set out (2 words)
17. _____ bender
19. Used to splice conductors and to unsplice soldered conductors (2 words)
20. Instrument used to measure circuit voltage and resistance (2 words)
23. Used to tighten couplings and connectors and to remove and hold nuts and bolts (2 words)
24. Used to pull wires or cables through EMT or pipe and to pull cables up insulated walls (4 words)
27. Pipe cutter spelled backwards
29. Tool used to manually bore holes (2 words)
35. Tool used for measuring
39. Tool used to notch wood for boxes and cables
42. Used to groom your hair
43. Man's name
44. Used to unlock doors

ELECTRICAL TOOLS
UNIT II

SOLUTION TO SUPPLEMENT #1



ELECTRICAL TOOLS
UNIT II

INFORMATION SHEET

I. Terms and definitions associated with electrical tools

A. **Set out** — Distance that boxes extend past the studs

B. **Cable** — Two or more conductors grouped together in an overall covering

C. **Conductor** — Material which permits the free flow of electrons

D. **Circuit** — Complete path for current to flow from source through the load and back to the source

E. **Splice** — Joining together of two or more conductors

F. **EMT** — Electrical Metallic Tubing

G. **Voltage** — Measure of the potential difference between conductors in a circuit

H. **Resistance** — Opposition to electron flow in a conductor or circuit

I. **Amperage** — Measurement of the rate of flow of current through a conductor

J. **Deburr** — To remove the burrs (roughness) caused from the cutting of the metal

II. Guidelines for care and safe use of electrical tools

A. Pouch tools

1. Use the correct tool for the job
2. Keep tools sharp
3. Keep tools clean
4. Inspect tools frequently to make sure they are in good condition
5. Repair broken o100000%%[Printr damaged tools promptly
6. Dispose of broken or damaged tools that cannot be repaired
7. Store tools properly when not in use
8. Stay alert when using tools
9. Wear eye protection when necessary

INFORMATION SHEET

10. Lubricate tools when necessary

B. Specialty tools

1. Use the correct tool for the job
2. Keep tools clean
3. Keep cutting tools sharp and in good working condition
4. Keep all cutting edges properly protected
5 Keep moving parts properly lubricated
6. Inspect tools and accessories regularly
7. Keep tools in their proper place when not in use
8. Avoid bumping or jolting meters and testing equipment
9. Avoid exposure of meters and testing equipment to extreme temperature
10. Keep all tools and equipment dry

III. Pouch tools and their common trade uses

A. Folding rule or steel tape — Used to check measurements on prints, locate boxes, and determine depth and setout

FIGURE 1

FIGURE 2

B. Screwdrivers

1. Flat blade (standard) screwdriver — Used to remove and install slot head screws and to tighten and loosen slot head lugs

FIGURE 3

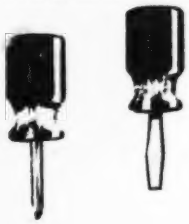
INFORMATION SHEET

2. Phillips head screwdriver — Used to remove and install Phillips head screws and to tighten and loosen Phillips head lugs

FIGURE 4

3. Stubby screwdriver — Used to remove and install screws in limited working space and to tighten and loosen lugs in limited working space

FIGURE 5



C. Pliers

1. Sidecut pliers — Used to cut cables, conductors, small screws; strip conductors; form large conductors; and pull and hold conductors

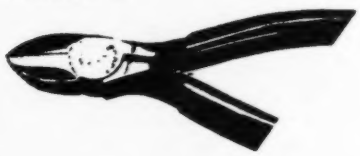
FIGURE 6

2. Long-nose pliers — Used to form small conductors, strip conductors, cut conductors, and to hold and pull conductors

FIGURE 7

3. Diagonal pliers — Used to cut cables and conductors in limited space and to strip conductors

FIGURE 8



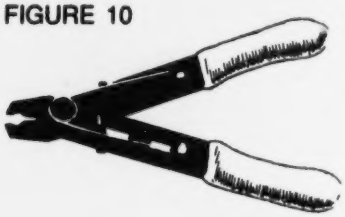
INFORMATION SHEET

4. Channel-lock pliers (groove-lock) — Used to hold and tighten couplings and connectors and to hold and turn conduit and tubing

FIGURE 9

D. Adjustable wire strippers — Used to strip insulation from conductors and to cut and form conductors

FIGURE 10

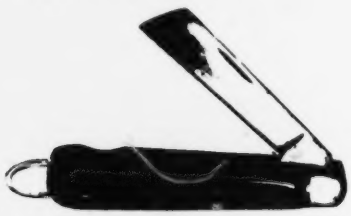


E. Six-in-one tool — Used to strip insulation, cut conductors, and to cut small bolts

FIGURE 11

F. Pocket knife — Used to open cartons and to strip large conductors and cables

FIGURE 12



INFORMATION SHEET

G. Tap tool — Used to tap holes for securing equipment to metal, enlarge holes and tap for larger screws, retap damaged threads, and to determine screw sizes.

FIGURE 13

H. Adjustable wrench — Used to tighten couplings and connectors, tighten pressure-type wire connectors, and to remove and hold nuts and bolts

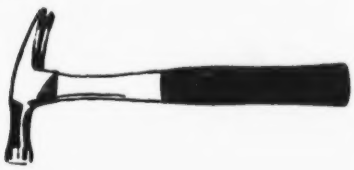
FIGURE 14

I. Awl — Used to start screw holes, make pilot holes for drilling, and to mark metal

FIGURE 15

J. Electrician's hammer — Used to drive and pull nails, pry boxes loose, chip wood, break wall board, and to strike chisels

FIGURE 16

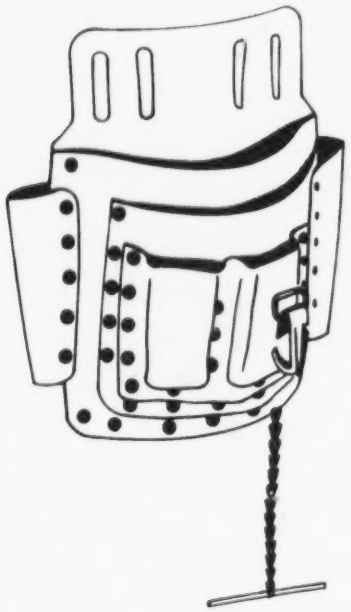


K. Neon test light — Used to check for live circuits and to identify conductors

FIGURE 17

L. Tool pouch — Used to hold, organize, and carry electricians tools

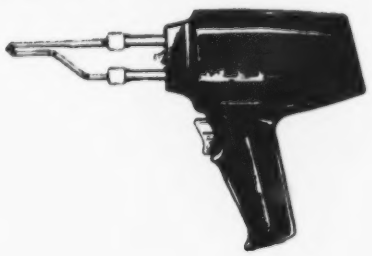
FIGURE 18



IV. Types of specialty tools and their common trade uses

A. Soldering gun — Used to splice conductors and to unsplice soldered conductors

FIGURE 19



INFORMATION SHEET

B. Hacksaw — Used to cut EMT, pipe, and large conductors and cables

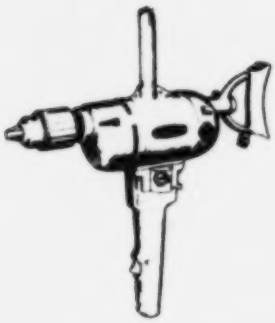
FIGURE 20

C. Bit brace — Used to manually bore holes for cables, conduits, and pipe

FIGURE 21

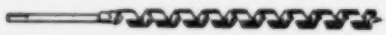
D. Drill motor — Used to bore holes for cables, conduits, and pipes when electricity is available

FIGURE 22



E. Ship auger bit — Used in bit brace or drill motor to bore holes

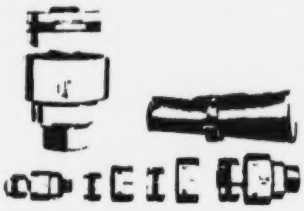
FIGURE 23



INFORMATION SHEET

F. Knockout punch — Used to cut holes for cable or conduit fittings in metal boxes, equipment, and appliances and for enlarging holes in metal boxes, equipment, and appliances

FIGURE 24



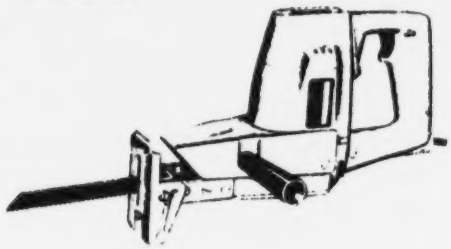
G. Saws

1. Keyhole saw — Used to cut holes in wall board for boxes and to cut exposed lath for box installation

FIGURE 25

2. Reciprocating saw — Used to cut heavy lumber and to cut off pipe, lumber, and fasteners flush to surface

FIGURE 26



INFORMATION SHEET

H. Fish tape and reel — Used to pull wires or cables through EMT or pipe and to pull cables up insulated walls

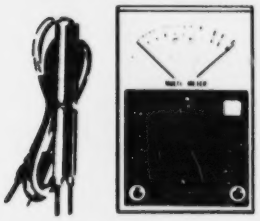
FIGURE 27

I. Drop chain — Used to pull cables in walls

FIGURE 28

J. Volt ohmmeter — Used to measure circuit voltage and resistance and to check for voltage and continuity

FIGURE 29



K. Ammeter — Used to check amperage, individual load amperage, and motor starting and running current

FIGURE 30

INFORMATION SHEET

L. Hickey bender — Used to bend heavy wall conduit

FIGURE 31

M. EMT bender — Used to bend EMT

FIGURE 32

N. Level — Used to level or plumb conduit, equipment, and appliances

FIGURE 33

Torpedo

Utility

O. Plumb bob — Used to transfer location points from ceiling to floor or floor to ceiling and to plumb conduit and equipment

FIGURE 34

INFORMATION SHEET

P. File — Used to deburr conduit, sharpen tools, and cut and form metal

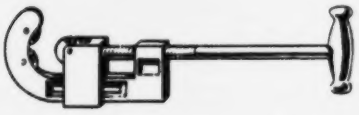
FIGURE 35

Q. Chisel — Used to notch wood for boxes and cables

FIGURE 36

R. Pipe cutter — Used to cut pipe and conduit

FIGURE 37



S. Pipe reamer — Used in a bit brace or machine to deburr pipe and conduit

FIGURE 38

T. Cable cutter — Used to cut large size cables

FIGURE 39

INFORMATION SHEET

U. Pipe vise and stand — Used to hold pipe and conduit while cutting and deburring and to hold pipe while threading

FIGURE 40

V. Factors to consider when buying tools

A. Match tool size to the work most frequently encountered

B. Use tools that are specifically designed for electrical use

EXAMPLES: Handles should be insulated
Hammers should have straight claws
Pliers should have stripping slots

C. Know specifications before purchasing tools

EXAMPLES: Sidecut pliers — 9" with high leverages, insulated grips, and number 12 stripping slot

Long-nose pliers — 7" with insulated grip and number 12 stripping slot

Flat-blade screwdriver — Electrician's round shank, 6" x 3/16" blade with insulated grips

D. Buy a pouch large enough to hold all the tools you will carry

E. Be sure the range limits of meters and testing equipment are enough to handle the jobs you will be doing

F. Buy only quality tools

ELECTRICAL TOOLS
UNIT II

JOB SHEET #1 — CUT CABLE USING SIDECUT PLIERS

I. Tools and equipment

A. Sidecut pliers

B. Length of cable

(NOTE: Since 12-2G is the most commonly used cable in residential wiring, you will probably want to use it.)

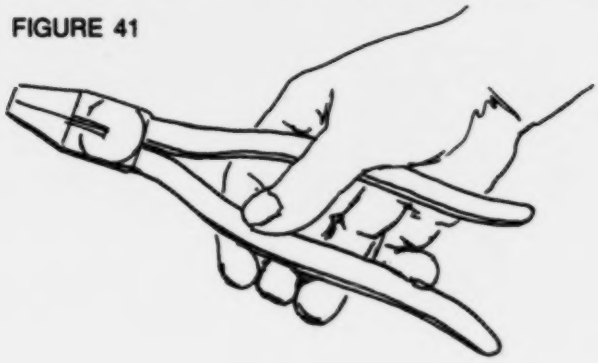
C. Safety glasses

II. Procedure

A. Put on safety glasses

(NOTE: Possibly the most important lesson to be learned in this job sheet is the positioning of the little finger. Figure 41)

FIGURE 41

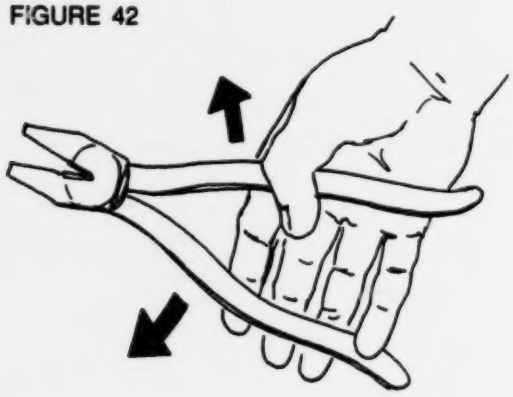


JOB SHEET #1

B. Open cutting jaws (Figure 42)

(NOTE: One handle is secured by the thumb; the other is pushed with the little finger.)

FIGURE 42



C. Put wire into the cutting jaws (Figure 43)

(NOTE: The little finger is now on outside of plier handle ready to apply leverage.)

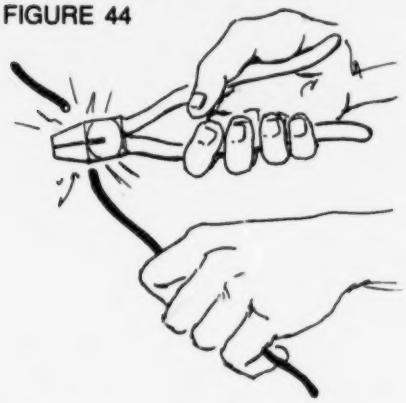
FIGURE 43

JOB SHEET #1

D. Cut off the piece of cable (Figure 44)

(NOTE: Eventually, reflex action will cause the little finger to reposition itself to Figure 41 position after cutting action.)

FIGURE 44



E. Repeat process until proficient

ELECTRICAL TOOLS
UNIT II

JOB SHEET #2 — ADJUST WIRE STRIPPERS

I. Tools and equipment

A. Adjustable wire strippers

(NOTE: The strippers should be adjusted for stripping the most commonly used conductor in your area.)

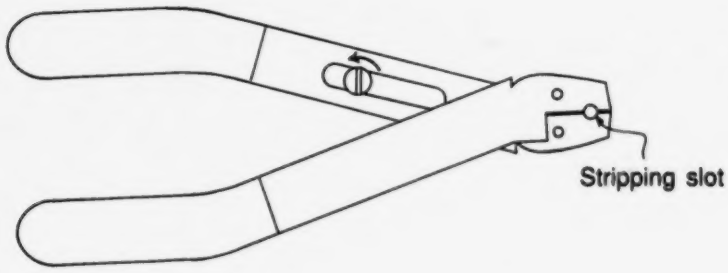
B. 12- or 14-gauge solid insulated conductor

C. Screwdriver or nut driver to fit adjustment screw

II. Procedure

A. Loosen adjustment screw (Figure 45)

FIGURE 45



B. Insert conductor in stripping slot

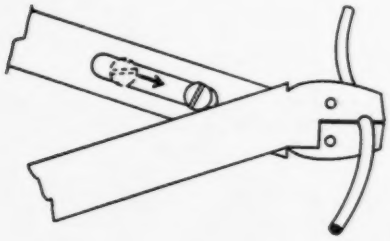
C. Close jaws until you feel that you have reached the conductor

D. Open the jaws slightly

JOB SHEET #2

E. Slide the adjustment screw down to its resting position (Figure 46)

FIGURE 46



F. Strip off a fresh piece of insulation

G. Check conductor for ring or nick (Figure 47)

(NOTE: If nick occurs, loosen adjustment screw, move it back slightly, retighten, and test again until insulation is cut without conductor damage.)

FIGURE 47

Correctly adjusted

Incorrectly adjusted

ELECTRICAL TOOLS
UNIT II

JOB SHEET #3 — TRIM CONDUCTOR INSULATION USING A KNIFE

I. Tools and equipment

A. Pocket knife

B. Insulated conductor

C. Safety glasses

II. Procedure

A. Put on safety glasses

B. Place knife blade on length of insulation to be removed (Figure 48)

FIGURE 48

CAUTION:
Never cut toward yourself when trimming conductor insulation.

C. Push knife through stroke to remove chip (Figure 49)

(NOTE: Be careful and do not nick your conductor in this process.)

FIGURE 49

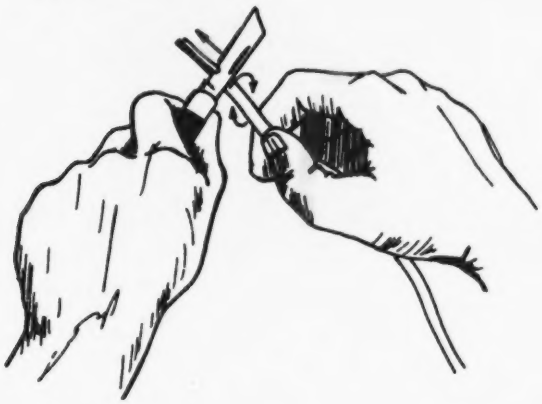
JOB SHEET #3

D. Rotate the conductor

E. Remove another chip (Figure 50)

(NOTE: Try to start all knife strokes evenly.)

FIGURE 50



F. Rotate and trim until insulation is removed (Figure 51)

FIGURE 51

ELECTRICAL TOOLS
UNIT II

JOB SHEET #4 — USE A SOLDERING GUN TO SPLICE CONDUCTORS

I. Tools and equipment

A. Soldering gun

B. Sidecut pliers

C. Wire strippers

D. Safety glasses

E. Rosin core solder

(NOTE: Rosin core or solder and flux are acceptable.)

F. Two 6" pieces of copper conductor

II. Procedure

A. Put on safety glasses

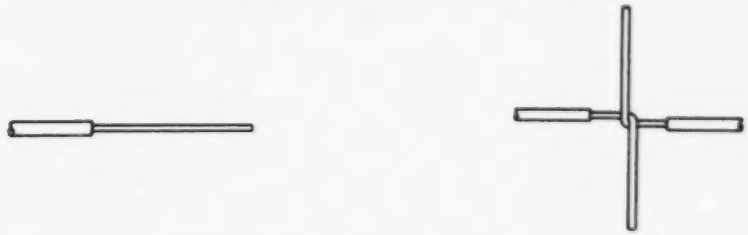
B. Strip approximately 1" of insulation from the conductor

C. Form a splice (Figure 52)

(NOTE: Any solid splice will work. Two types are illustrated here.)

STRAIGHT SPLICE

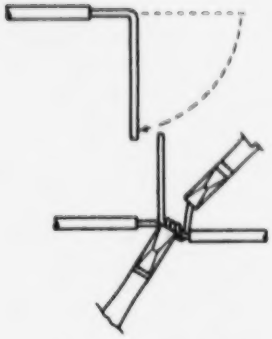
FIGURE 52



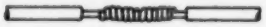
1. Bend 90-degree angles in both conductors

2. Hook conductors together

JOB SHEET #4



3. Hold one conductor secure while wrapping the other



4. Finished straight splice

TWIST SPLICE (PIGTAIL)

1. Lap conductors over each other

2. Twist tightly

D. Clean tip of soldering gun

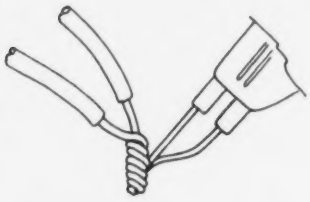
E. Heat gun tip

(NOTE: You can touch the solder to the gun tip to determine if it is hot enough.)

JOB SHEET #4

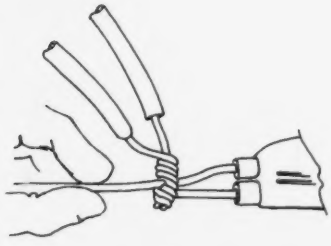
F. Put gun tip on underside of splice to heat it (Figure 53)

FIGURE 53



G. Apply solder to top of joint (Figure 54)

FIGURE 54



H. Remove soldering gun and solder stick from joint when it has filled

I. Have the instructor inspect the splice

J. Clean up tools and replace

ELECTRICAL TOOLS
UNIT II

JOB SHEET #5 — USE A KNOCKOUT PUNCH

I. Tools and equipment

A. Knockout punch

B. Drill motor

C. Metal drill

(NOTE: Drill must be large enough to let the knockout punch screw through the opening it makes.)

D. 10" adjustable wrench or 1/2" ratchet with socket to fit drive nut

E. Metal to be punched

(NOTE: Most punches are rated up to 10-gauge metal.)

F. Vise

(NOTE: A vise is needed if material to be cut is not fastened on a wall or is too small to stand on to hold.)

G. Safety glasses

H. Extension cord

II. Procedure

A. Put on safety glasses

B. Drill a hole slightly larger than the knockout punch bolt in the center of the space you are going to punch

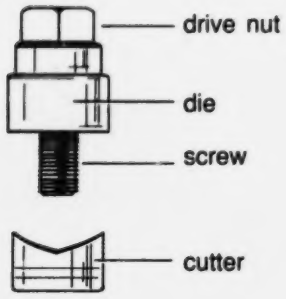
(NOTE: A center punch should be used to make an indentation for your drill to start in.)

CAUTION:
Hold the drill motor firmly while drilling. A loose grip could cause an accident. Remember that the drill will be hot so use caution around it until it cools.

JOB SHEET #5

C. Separate the knockout punch cutter from the die and screw (Figure 55)

FIGURE 55

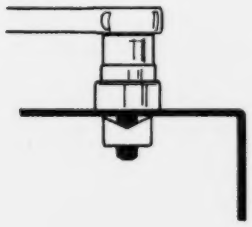


D. Insert bolt through drilled hole and put cutter back on screw (Figure 56)

FIGURE 56

E. Tighten drive nut with wrench or socket (Figure 57)

FIGURE 57



F. Remove knockout punch when cutter is finally pulled through (Figure 58)

FIGURE 58

JOB SHEET #5

G. Remove cutter from screw and shake out punched metal (Figure 59)

FIGURE 59

H. Replace cutter

(NOTE: Keep cutter lubricated)

I. Have instructor evaluate job

J. Put up tools and equipment

ELECTRICAL TOOLS
UNIT II

JOB SHEET #6 — BEND A 90-DEGREE STUB WITH 1/2" EMT

(NOTE: Due to the differences in bender shoe markings, the height of this bend and its determination will be left to the instructor.)

I. Tools and equipment

A. 1/2" EMT bender

B. 1/2" EMT (length optional)

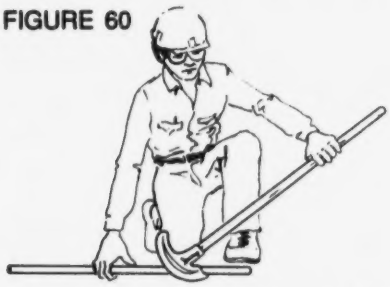
C. Safety glasses

II. Procedure

A. Put on safety glasses

B. Place the conduit in the bender jaw (Figure 60)

FIGURE 60

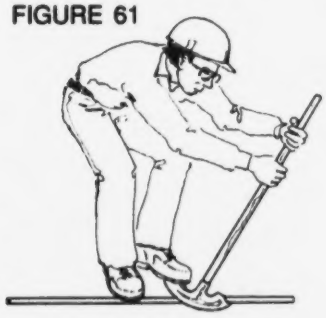


C. Apply light pressure on handle to hold conduit in place

D. Place one foot on bender kick pad

E. Place other foot on conduit (Figure 61)

FIGURE 61

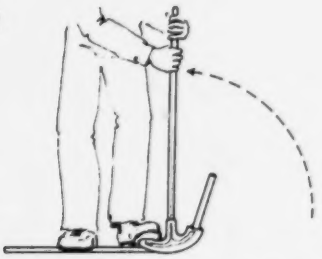


JOB SHEET #6

F. Apply heavy pressure on bender kick pad while pulling handle to a straight-up position (Figure 62)

(NOTE: If pressure is not applied solidly to kick pad, conduit can wrinkle or collapse.)

FIGURE 62



G. Reposition feet for comfort (Figure 63)

FIGURE 63

H. Reapply kick pad and bender handle pressure until bend is completed (Figure 64)

FIGURE 64

(NOTE: A square can be used to evaluate your accuracy until you develop your skills.)

ELECTRICAL TOOLS
UNIT II

JOB SHEET #7 — CUT RIGID CONDUIT WITH A PIPE CUTTER

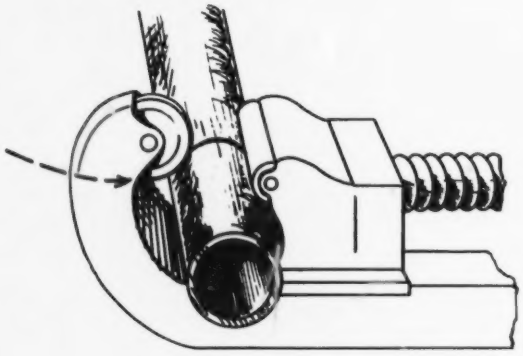
I. Tools and equipment

- A. Pipe vise
- B. Pipe cutter
- C. Rigid conduit
- D. Safety glasses
- E. Pencil

II. Procedure

- A. Put on safety glasses
- B. Secure conduit in vise
- C. Mark place for cut with pencil
- D. Open pipe cutter until it will fit over conduit
- E. Locate cutter wheel on the pencil mark (Figure 65)

FIGURE 65

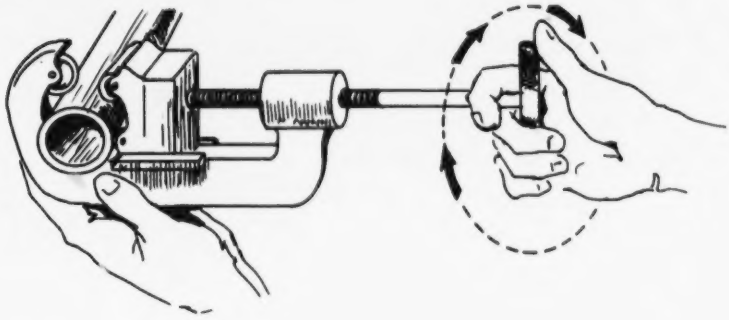


JOB SHEET #7

F. Snug cutter up to conduit by rotating screw handle (Figure 66)

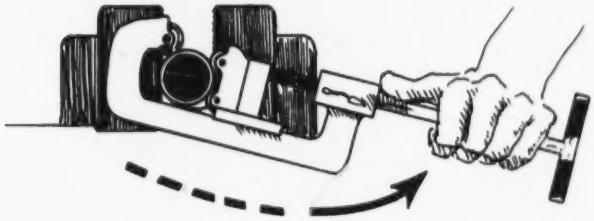
(NOTE: Don't overtighten as this can break cutter wheel.)

FIGURE 66



G. Rotate cutter counterclockwise to start groove (Figure 67)

FIGURE 67



H. Tighten cutter hand 1/4 of a turn for each full revolution around the pipe

(NOTE: Overtightening can cause cutters to break.)

CAUTION:
When cutting short pieces of conduit, be careful not to cut your arm while rotating the cutter around the pipe.

JOB SHEET #7

I. Continue process until conduit is cut

(NOTE: Be prepared to catch free piece of conduit.)

J. Have instructor inspect work

K. Put up tools and equipment

L. Clean up work area

ELECTRICAL TOOLS
UNIT II

JOB SHEET #8 — SET UP AND USE A HACKSAW

I. Tools and equipment

A. Hacksaw frame

B. Hacksaw blade

(NOTE: For cutting pipe or conduit, a 24- or 32-teeth inch blade is recommended.)

C. Pipe or conduit

D. Safety glasses

II. Procedure

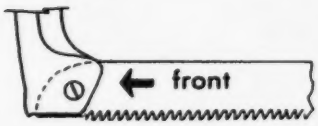
A. Put on safety glasses

B. Insert blade in frame (Figure 68)

FIGURE 68

(NOTE: Be sure teeth angles are pointed toward the front of the saw. Figure 69)

FIGURE 69

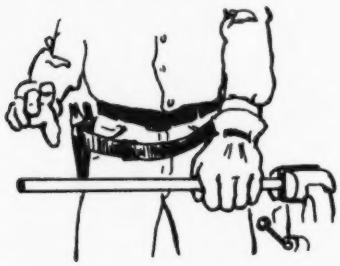


JOB SHEET #8

C. Secure pipe or conduit for cutting (Figure 70)

(NOTE: Short pieces of pipe are easier to cut in a vise.)

FIGURE 70



D. Reset the blade on the pipe or conduit at the point to be cut

E. Push forward gently until cut is started

(NOTE: Do not exert extra pressure on saw.)

F. Make reciprocal strokes until cut is finished

(NOTE: Excessive speed while cutting can ruin blades. You should not use over thirty full strokes per minute.)

G. Have the instructor check your cut (Figure 71)

(NOTE: Your cut should be straight and relatively smooth.)

FIGURE 71

Incorrect Correct

ELECTRICAL TOOLS
UNIT II

JOB SHEET #9 — REAM RIGID CONDUIT

I. Tools and equipment

A. Pipe vise

B. Reamer

(NOTE: You will need a ratchet handle or bit brace depending on which type of reamer is used.)

C. Piece of rigid conduit

D. Safety glasses

II. Procedure

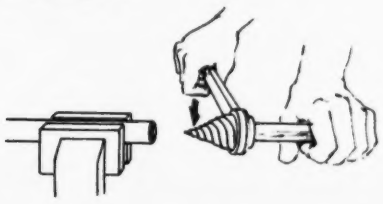
(NOTE: Be safety conscious around cut pieces of rigid conduit. Sharp ridges or spurs can cause deep cuts.)

A. Put on safety glasses

B. Place conduit in vise

C. Insert reamer tip in conduit (Figure 72)

FIGURE 72



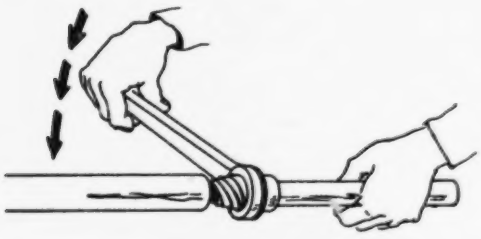
D. Apply light forward pressure to push reamer into conduit

JOB SHEET #9

E. Start rotating reamer (Figure 73)

(NOTE: Reamer should bite instantly if proper pressure is applied. Reamer can be damaged if rotated in the wrong direction.)

FIGURE 73



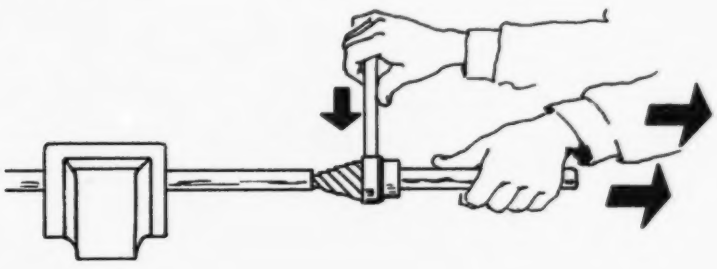
F. Rotate reamer until burrs are removed

(NOTE: This is a developed skill. The reamer can be pulled out and your progress inspected.)

G. Pull reamer back while continuing to rotate (Figure 74)

(NOTE: This prevents the reamer from leaving a burr.)

FIGURE 74



H. Have your instructor evaluate your work

I. Put up all tools and equipment

ELECTRICAL TOOLS
UNIT II

JOB SHEET #10 — USE A VOLT OHMMETER

I. Tools and equipment

A. Volt ohmmeter

B. Safety glasses

C. 125-volt duplex grounding receptacle

D. 250-volt grounding receptacle

E. Assorted fuses

II. Procedure

A. Read meter instructions

(NOTE: Some meters require a specific probe connection at the meter.)

B. Put on safety glasses

C. Set meter at highest A.C. scale

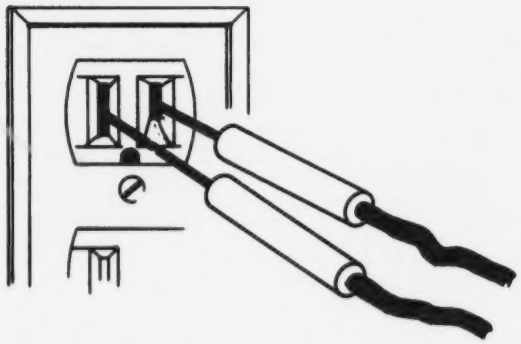
D. Check across grounded and ungrounded slots of 125-volt duplex grounding receptacle (Figure 75)

(NOTE: If reading on highest scale does not exceed the next lower scale, drop to it for a more accurate reading. Repeat this process until you are reading on the lowest possible scale.)

CAUTION:
Connecting a meter that is set on a scale lower than the actual circuit voltage could damage the meter.

JOB SHEET #10

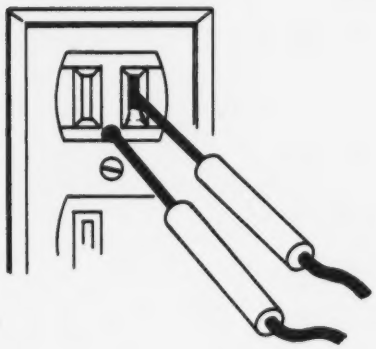
FIGURE 75



E. Check voltage across ungrounded (narrow slot) and grounding slot (Figure 76)

(NOTE: Again, start at the highest meter scale. A short in a multi-wire branch circuit can give a dual voltage reading in this test.)

FIGURE 76

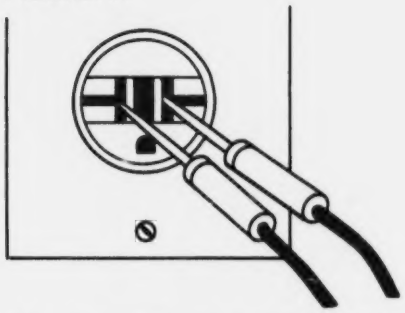


F. Reset meter to highest scale

JOB SHEET #10

G. Check across ungrounded slots of a 250-volt receptacle (Figure 77)

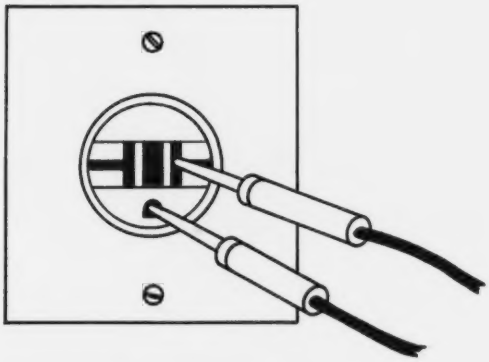
FIGURE 77



H. Reduce scale to most accurate possible reading

I. Read from each ungrounded conductor to the grounding conductor (Figure 78)

FIGURE 78



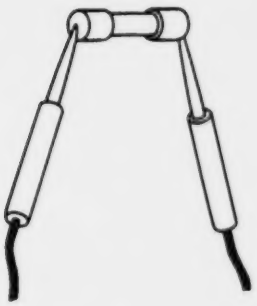
J. Change meter to ohm scale

JOB SHEET #10

K. Measure across fuse contacts for continuity (Figure 79)

(NOTE: A scale reading indicates that the fuse is good. No scale reading indicates the fuse is bad.)

FIGURE 79



ELECTRICAL TOOLS
UNIT II

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with electrical tools. Write the correct numbers in the blanks.

_____a.	Distance that the boxes extend past the studs	1.	Conductor
_____b.	Two or more conductors grouped together in an overall covering	2.	Amperage
_____c.	Material which permits the free flow of electrons	3.	Splice
_____d.	Complete path for current to flow from source through the load and back to the source	4.	Voltage
_____e.	Joining together of two or more conductors	5.	Set out
_____f.	Electrical metallic tubing	6.	Resistance
_____g.	Measure of the potential difference between conductors in a circuit	7.	Circuit
_____h.	Opposition to electron flow in a conductor or circuit	8.	Deburr
_____i.	Measurement of the rate of flow of current through a conductor	9.	Cable
_____j.	To remove the burrs (roughness) caused from the cutting of the metal	10.	EMT

TEST

2. State five guidelines for care and safe use of electrical tools. Write five guidelines for each of the following sets of tools.

   a. Pouch tools

      1. _____
      2. _____
      3. _____
      4. _____
      5. _____

   b. Specialty tools

      1. _____
      2. _____
      3. _____
      4. _____
      5. _____

TEST

3. Match to their common trade uses the following pouch tools. Write the correct numbers in the blanks.

_____a.	Used to check measurements on prints, locate boxes, and determine depth and set out	1.	Channel-lock pliers
_____b.	Used to remove and install slot head screws and to tighten and loosen slot head lugs	2.	Sidecut pliers
_____c.	Used to remove and install Phillips head screws and to tighten and loosen slot head lugs	3.	Adjustable wrench
_____d.	Used to remove and install screws in limited working space and to tighten and loosen lugs in limited work space	4.	Adjustable wire strippers
_____e.	Used to cut cables, conductors, small screws; strip conductors; form large conductors; and pull and hold conductors	5.	Pocket knife
_____f.	Used to form small conductors, strip conductors, cut conductors, and to hold and pull conductors	6.	Tool pouch
_____g.	Used to cut cables and conductors in limited space and to strip conductors	7.	Phillips head screwdriver
_____h.	Used to hold and tighten couplings and connectors and to hold and turn conduit and tubing	8.	Electrician's hammer
_____i.	Used to strip insulation from conductors and to cut and form conductors	9.	Folding rule
_____j.	Used to strip insulation, cut conductors, and cut small bolts	10.	Tap tool
_____k.	Used to open cartons and strip large conductors and cables	11.	Long-nose pliers
_____l.	Used to tap holes for securing equipment to metal, enlarge holes and tap for larger screws, retap damaged threads, and to determine screw sizes	12.	Six-in-one tool

TEST

_____m.	Used to tighten couplings and connectors, tighten pressure-type wire connectors, and to remove and hold nuts and bolts	13.	Stubby screwdriver
		14.	Neon test light
_____n.	Used to start screw holes, make pilot holes for drilling, and to mark metal	15.	Flat blade screwdriver
_____o.	Used to drive and pull nails, pry boxes loose, chip wood, break wall board, and strike chisels	16.	Awl
		17.	Diagonal pliers
_____p.	Used to check for live circuits and to identify conductors		
_____q.	Used to hold, organize, and carry electrician's tools		

4. Match to their common uses the following specialty tools. Write the correct numbers in the blanks.

_____a.	Used to splice conductors and to unsplice soldered conductors	1.	Drill motor
		2.	Drop chain
_____b.	Used to cut EMT, pipe, and large conductors and cables	3.	Keyhole saw
_____c.	Used to manually bore holes for cables, conduits, and pipe	4.	Pipe cutter
		5.	Hickey bender
_____d.	Used to bore holes for cables, conduits, and pipes when electricity is available	6.	Plumb bob
_____e.	Used in bit brace or drill motor to bore holes	7.	Hacksaw
_____f.	Used to cut holes for cable or conduit fittings in metal boxes, equipment, and appliances for enlarging holes in metal boxes, equipment, and appliances	8.	Cable cutter
		9.	Reciprocating saw
_____g.	Used to cut holes in wall board for boxes and to cut exposed latch for box installation		
_____h.	Used to cut heavy lumber and to cut off pipe, lumber, and fasteners flush to surface		
_____i.	Used to pull wires or cables through EMT or pipe and to pull cables up insulated walls		

TEST

_____j. Used to pull cables in walls

_____k. Used to measure circuit voltage and resistance and to check for voltage and continuity

_____l. Used to check amperage, individual load amperage, and motor starting and running current

_____m. Used to bend heavy wall conduit

_____n. Used to bend EMT

_____o. Used to level or plumb conduit, equipment, and appliances

_____p. Used to transfer location points from ceiling to floor or floor to ceiling and to plumb conduit and equipment

_____q. Used to deburr conduit, sharpen tools, and cut and form metal

_____r. Used to notch wood for boxes and cables

_____s. Used to cut pipe and conduit

_____t. Used in a bit brace or machine to deburr pipe and conduit

_____u. Used to cut large size cables

_____v. Used to hold pipe and conduit while cutting and deburring and to hold pipe while threading

10. Volt ohmmeter
11. Ship auger bit
12. Level
13. Fish tape and reel
14. Chisel
15. Soldering gun
16. Pipe reamer
17. Ammeter
18. Pipe vise and stand
19. Knockout punch
20. File
21. EMT bender
22. Bit brace

TEST

5. List three factors to consider when buying tools:

   a. _____

   _____

   b. _____

   _____

   c. _____

   _____

(NOTE: Test question 6 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

6. Demonstrate the ability to

   a. Cut cable using sidecut pliers

   b. Adjust wire strippers

   c. Trim conductor insulation using a knife

   d. Use a soldering gun to splice conductors

   e. Use a knockout punch

   f. Bend a 90-degree stub with 1/2" EMT

   g. Cut rigid conduit with a pipe cutter

   h. Set up and use a hacksaw

   i. Ream rigid conduit

   j. Use a volt ohmmeter

ELECTRICAL TOOLS
UNIT II

ANSWERS TO TEST

1.

a.	5		f.	10	
b.	9		g.	4	
c.	1		h.	6	
d.	7		i.	2	
e.	3		j.	8	

2. Answer should include any five of the following for each electrical tool

   a. Pouch tools
      1. Use the correct tool for the job
      2. Keep tools sharp
      3. Keep tools clean
      4. Inspect tools frequently to make sure they are in good condition
      5. Repair broken or damaged tools promptly
      6. Dispose of broken or damaged tools that cannot be repaired
      7. Store tools properly when not in use
      8. Stay alert when using tools
      9. Wear eye protection when necessary
      10. Lubricate tools when necessary

   b. Specialty tools
      1. Use the correct tool for the job
      2. Keep tools clean
      3. Keep cutting tools sharp and in good working condition
      4. Keep all cutting edges properly protected
      5. Keep moving parts properly lubricated
      6. Inspect tools and accessories regularly
      7. Keep tools in their proper place when not in use
      8. Avoid bumping or jolting meters and testing equipment
      9. Avoid exposure of meters and testing equipment to extreme temperature
      10. Keep all tools and equipment dry

3.

a.	9		g.	17	
b.	15		h.	1	
c.	7		i.	4	
d.	13		j.	12	
e.	2		k.	5	
f.	11		l.	10	
			m.	3	
			n.	16	
			o.	8	
			p.	14	
			q.	6	

ANSWERS TO TEST

4.

a.	15	g.	3	m.	5	s.	4
b.	7	h.	9	n.	21	t.	16
c.	22	i.	13	o.	12	u.	8
d.	1	j.	2	p.	6	v.	18
e.	11	k.	10	q.	20		
f.	19	l.	17	r.	14		

5. Answer should include any three of the following:

   a. Match tool size to the work most frequently encountered
   b. Use tools that are specifically designed for electrical use
   c. Know specifications before purchasing tools
   d. Buy a pouch large enough to hold all the tools you will carry
   e. Be sure the range limits of meters and testing equipment are enough to handle the jobs you will be doing
   f. Buy only quality tools

6. Performance skills evaluated to the satisfaction of the instructor

ELECTRICAL LAYOUT
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to distinguish between wiring diagrams and schematics; locate receptacles, switches, and lighting outlets on floor plans; and install various types of boxes in various types of walls. The student will show this knowledge by completing the assignment sheets, job sheets, and unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. Match terms associated with electrical layout to their correct definitions.
2. Match electrical schematic symbols to their correct names.
3. Distinguish between wiring diagrams and schematics.
4. Draw a schematic of a simple series circuit.
5. State rules for series circuits.
6. List common applications for series circuits.
7. Draw a schematic of a simple parallel circuit.
8. State rules for parallel circuits.
9. List common applications of parallel circuits.
10. Select from a list good planning techniques when locating boxes on plans.
11. List accepted heights for boxes in various locations.
12. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a floor plan according to minimum requirements.
13. Locate receptacle outlets along kitchen counters on a floor plan according to minimum requirements.
14. Demonstrate the ability to:
    a. Install a device box when given cabinet height and wall coverings.
    b. Install a lighting outlet box when given wall covering thickness.
    c. Install a box with drywall grips in a drywall wall.

SPECIFIC OBJECTIVES

d. Secure a box with drywall supports (Boxtins).

e. Install a box in a concrete block wall.

f. Install a box in a ceiling with an accessible attic.

ELECTRICAL LAYOUT
UNIT III

SUGGESTED ACTIVITIES

I. Unit contents

- A. Objective sheet
- B. Suggested activities
- C. Transparency masters
  1. TM #1 — Rules for Series Circuits
  2. TM #2 — Rules for Parallel Circuits
- D. Information sheet
- E. Assignment sheets
  1. Assignment Sheet #1 — Locate Receptacle, Switch, and Lighting Outlets Along a Floor Line and the Ceiling on a Floor Plan
  2. Assignment Sheet #2 — Locate Receptacle Outlets Along Kitchen Counters on a Floor Plan
- F. Answers to assignment sheets
- G. Job sheets
  1. Job Sheet #1 — Install a Device Box When Given Cabinet Height and Wall Coverings
  2. Job Sheet #2 — Install a Lighting Outlet Box When Given Wall Covering Thickness
  3. Job Sheet #3 — Install a Box with Drywall Grips in a Drywall Wall
  4. Job Sheet #4 — Secure a Box with Drywall Supports (Boxtins)
  5. Job Sheet #5 — Install a Box in a Concrete Block Wall
  6. Job Sheet #6 — Install a Box in a Ceiling with Accessible Attic
- H. Test
- I. Answers to test

SUGGESTED ACTIVITIES

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Copies of electrical plans

2. Tools and materials needed to complete job sheets

3. Transparencies and competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Introduce unit to students.

- Invite an electrical contractor to discuss electrical tools, materials, and layout with the students.

- Visit a construction site to let students observe electrical layouts and box installations.

D. Provide students with objective sheet.

E. Discuss unit and specific objectives.

F. Provide students with information, assignment, and job sheets.

G. Discuss information, assignment, and job sheets.

1. Use Information Sheet, Section I, to discuss terms and definitions associated with electrical layout.

- Discuss, show samples of, or demonstrate terms that may be unfamiliar to students.

- Have students review terms.

2. Use Information Sheet, Section II, to discuss electrical schematic symbols.

- Select plans obtained to supplement unit and have students identify the different symbols found on the plans.

- Have students review the schematic symbols found in the information section.

SUGGESTED ACTIVITIES

3. Use Information Sheet, Sections III through IX, to discuss wiring diagrams and schematics, rules for series and parallel circuits, and common applications for series and parallel circuits.

   - Show students illustrations of schematic and diagram circuits, and discuss the rules for series and parallel circuits.
   - Discuss the common applications for series and parallel circuits and the differences in the two types of circuits.

4. Use Information Sheet, Sections X through XII, to discuss good planning techniques when locating boxes on plans, accepted heights for boxes in various locations and locating receptacles, switches, and lighting outlets according to minimum requirements.

   - Invite an architect to the class to discuss locations, heights, and minimum requirements for switch boxes, receptacle boxes, and lighting outlets. Discuss good planning techniques.
   - Visit a residential job and a commercial job and have students note the differences in the layout of different boxes and different heights of boxes, if any.
   - Have students complete Assignment Sheets #1 and #2. Critique them and discuss them in class.

5. Demonstrate procedures for the job sheets and then have students demonstrate the procedures and complete the job sheets.

H. Give test.

I. Critique test and discuss in class.

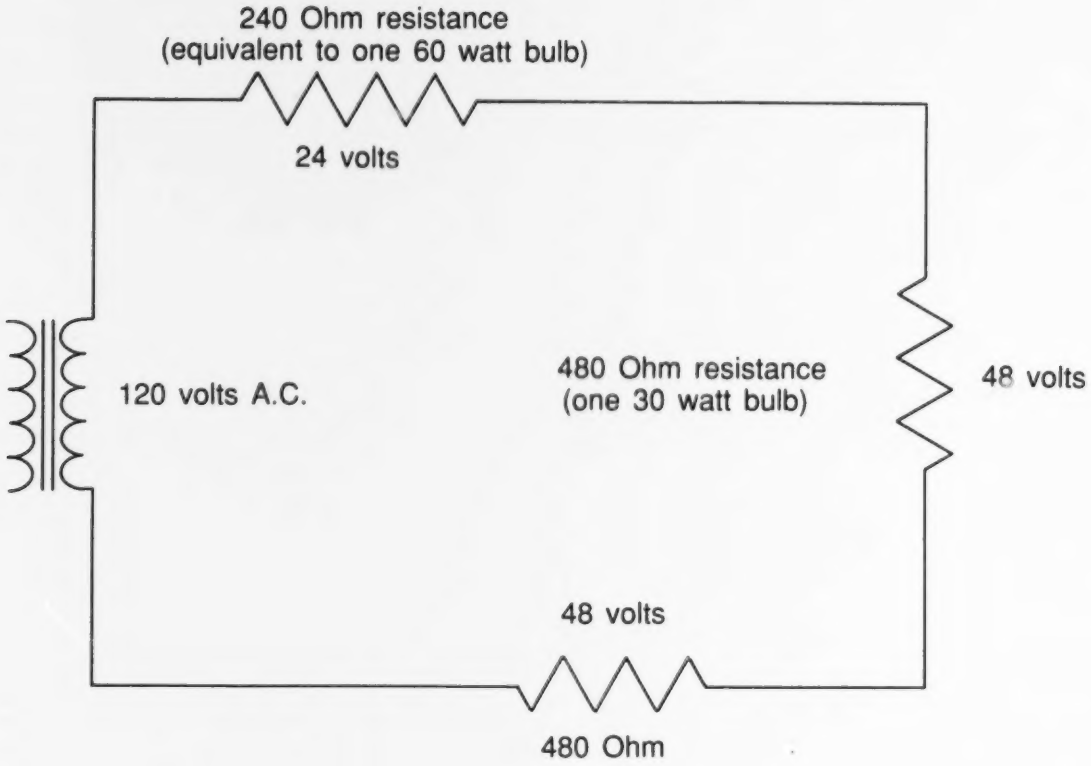
J. Reteach and retest if necessary.

K. Complete appropriate section of competency profiles.

III. Unit reference--

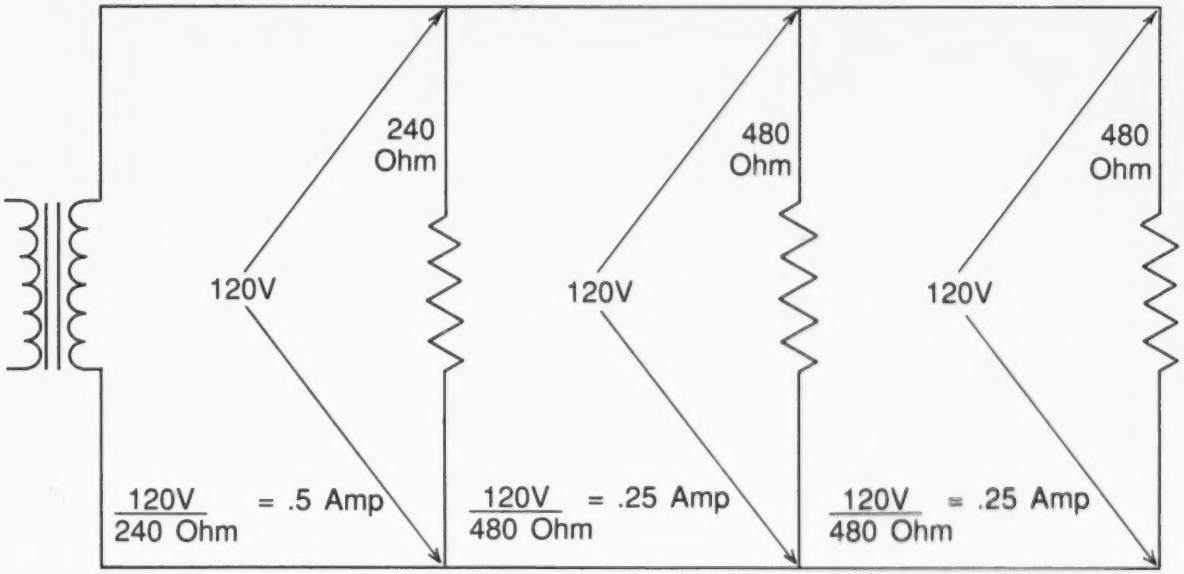
Taylor, Mark. *Residential Wiring*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1978. Revised 1983.

Series Circuit Rules



Total volts = 24 + 48 + 48
Highest resistance has highest voltage drop
Total Ohms = 240 + 480 + 480
Total current = 120/1200

Rules for Parallel Circuits



Total current = .5 + .25 + .25 = 1 amp
Voltage is equal across all branches
Total resistance = less than branches
120V/1 Amp = 120 Ohms
Total power = 60 + 30 + 30 = 120 watts

ELECTRICAL LAYOUT
UNIT III

INFORMATION SHEET

I. Terms and definitions associated with electrical layout

A. **Schematic** — Design of parts in a pattern according to a scheme

B. **Diagram** — Drawing that shows arrangement and relation to parts

C. **Circuit** — Complete path for current to flow from the source through the load and back to the source

D. **Series circuit** — Electrical circuit with all loads installed in a single path

E. **Parallel circuit** — Electrical circuit with all loads installed across circuit conductors

F. **Voltage** — Measure of the potential difference between conductors in a circuit

G. **Resistance** — Opposition to electron flow in a conductor or circuit

H. **Overcurrent device** — Current-limiting element in a circuit

I. **Box setout** — Distance that the box extends past the stud

J. **Flush** — Even with the surface

K. **GFCI** — Grounded Fault Circuit Interrupter

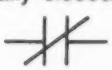
II. Schematic symbols

A. Transformer

B. Contact

1. Normally open

2. Normally closed



C. Fuse

D. Fixed bimetal thermostat

INFORMATION SHEET

E. Resistor or load

1. Fixed

2. Variable

F. Ground connection

G. Wire crossover

H. Wire connection

I. Single pole single throw switch

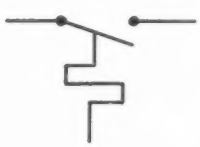
J. Three way switch

K. Four way switch

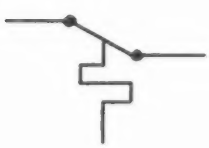
L. Single phase motor

M. Thermostat

1. Closes on rise

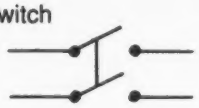


2. Opens on rise



INFORMATION SHEET

N. Double-pole single-throw switch



III. Diagrams and schematics

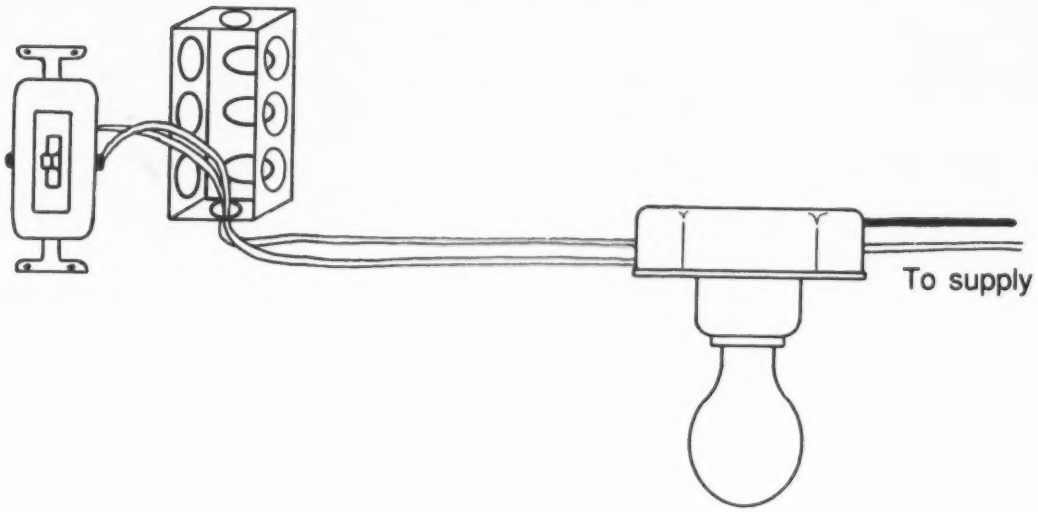
A. Diagrams

1. Drawing type illustrations

2. Illustrations are of actual equipment and devices

EXAMPLE:

FIGURE 1



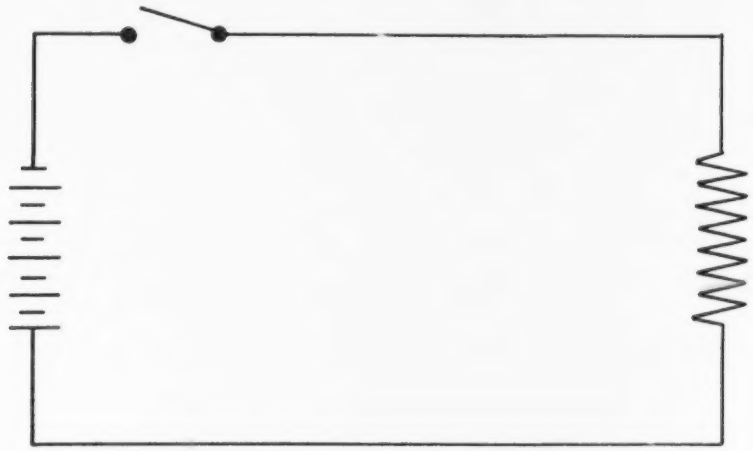
INFORMATION SHEET

B. Schematics

1. Line-type illustrations
2. Use standard schematic symbols for equipment and devices

EXAMPLE:

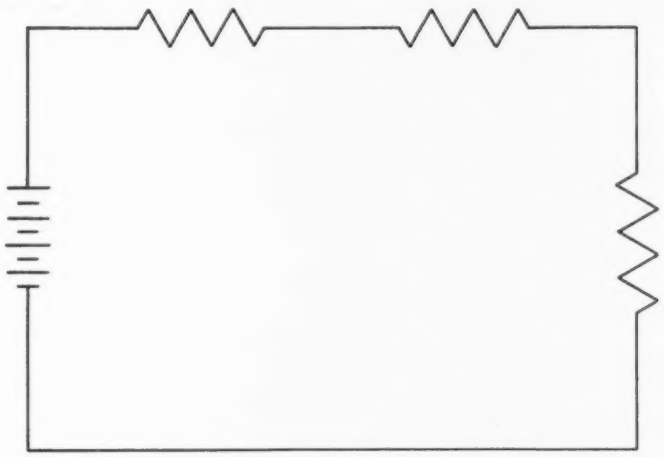
FIGURE 2



IV. Schematic of a simple series circuit

EXAMPLE:

FIGURE 3



One current path

INFORMATION SHEET

V. Rules for series circuits

A. The sum of the voltages across the individual components equals the voltage applied to the circuit

B. The largest voltage drop occurs in the component with the highest resistance

C. The sum of the resistance of the components equals the total resistance

D. Current is the same through all components of a series circuit

VI. Common applications for series connections

A. Switches

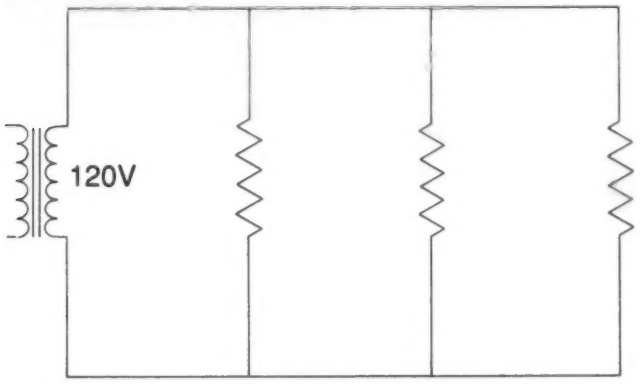
B. Overcurrent devices

C. Thermal protection devices

VII. Schematic of a simple parallel circuit

EXAMPLE:

FIGURE 4



Circuit has branch paths

VIII. Rules for parallel circuits

A. Total current equals the sum of all currents of the branches

B. Voltage is the same across all branches

INFORMATION SHEET

C. Total resistance in a parallel circuit is always less than the individual branches

EXAMPLE: Resistance of individual branches of two ten-ampere loads on a 120-volt circuit equals

$$\frac{E}{I} = R = \frac{120}{10} = 12 \text{ Ohms}$$

12 Ohms per branch is more than the total resistance of:

$$\frac{E}{I} = R = \frac{120}{20} = 6 \text{ Ohms}$$

D. Total power consumed in a parallel circuit equals the sum of the power consumed in the branches.

IX. Common applications of parallel circuits

A. Supplying receptacle outlets

B. Supplying light fixtures

X. Good planning techniques when placing boxes on plans

A. Keep spacing even where possible

B. Put boxes in even groups if possible

C. Check door swing so switches are not behind doors

D. Place outside lighting outlets low enough for any fixture

XI. Accepted heights for boxes in various locations

(NOTE: Check with cabinetmaker on how tall the cabinets are going to be if you are unfamiliar with her/his work.)

A. Above kitchen counter tops— 45" to box center

(NOTE: Tops are usually 36"; 1/2 of 18" backsplash equals 9", total height is then 45".)

B. Above bathroom cabinets—40" to box center

(NOTE: This allows for 44" or higher tile cap.)

C. Receptacles along floor line—12" to box center

D. Wall Switches—48" to box center

(NOTE: This allows drywall installers to cut one-half of box in each sheet when installing drywall horizontally.)

INFORMATION SHEET

XII. Location of receptacles, switches, and lighting outlets

A. Receptacle outlets

1. General provisions — In every kitchen, family room, dining room, living room, or similar rooms of dwelling units, receptacle outlets shall be installed so that no point along the floor line in any wall space is more than 6 feet measured horizontally, from an outlet in that space, including any wall space 2 feet or more in width and the space occupied by sliding panels in exterior doors. This wall space afforded by fixed room dividers such as free standing bar type counters, shall be included in the 6' measurement.

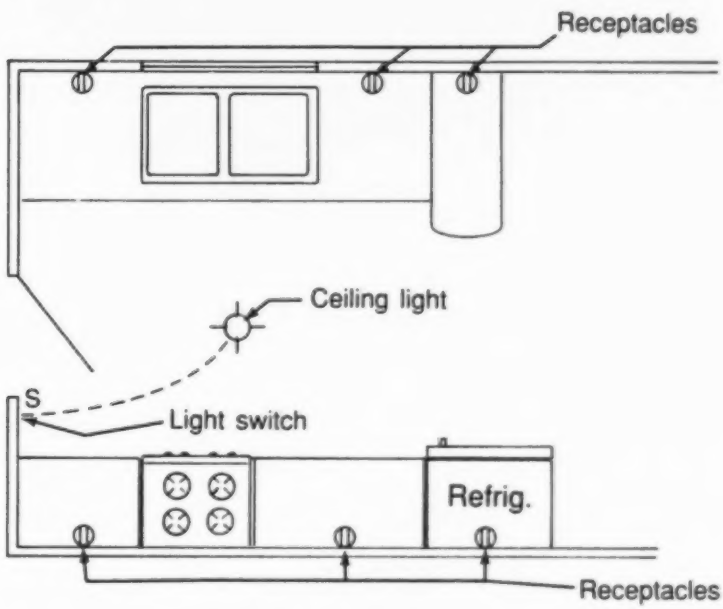
   (NOTE: A wall space shall be considered a wall unbroken along a floor line by doorways, fire places, or similar openings. Each wall space 2 feet wide or greater shall be treated individually and separately from other wall spaces. A wall space can include two or more walls [around corners] where unbroken at the floor line.)

2. Counter top — In kitchen and dining areas of dwelling units a receptacle outlet shall be installed at each counter space wider than 12 inches.

   (NOTE: Counters divided by ranges, sinks, or refrigerators shall be considered separate cabinets. The receptacle behind the refrigerator can be considered accessible.

   EXAMPLE:

   FIGURE 5



3. Bathrooms — At least one GFCI receptacle outlet shall be installed adjacent to the basin location

4. Outdoors — At least one GFCI receptacle outlet shall be installed outdoors

INFORMATION SHEET

5. Laundry areas — At least one receptacle outlet shall be installed in laundry areas

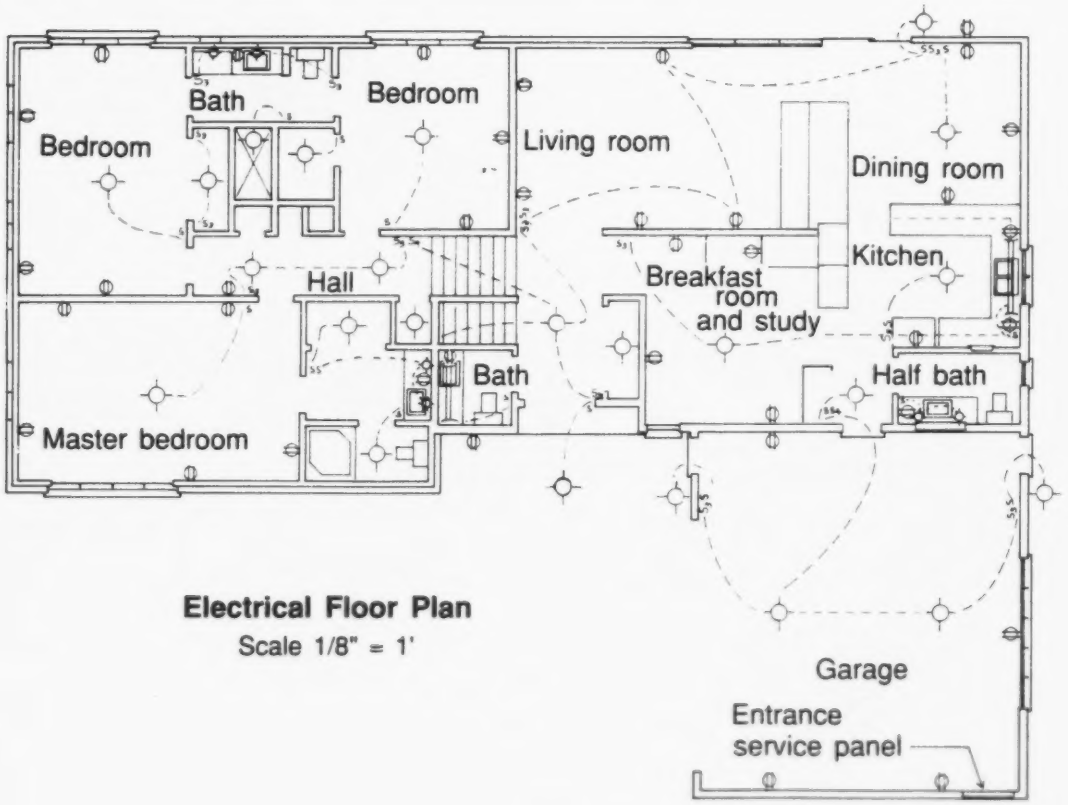
6. Basements and attached garages — At least one receptacle outlet shall be installed in addition to any for laundry equipment

B. Lighting outlets required — At least one wall switch controlling a lighting outlet in every habitable room, hallway, bathroom, stairway, attached garage, outdoor entrance, and in attics, under floor space, utility rooms and basements if used for storage or if containing equipment requiring service.

(NOTE: In habitable rooms, other than kitchens or bathrooms, one or more receptacles controlled by a wall switch shall be permitted in lieu of lighting outlets.)

EXAMPLE:

FIGURE 6

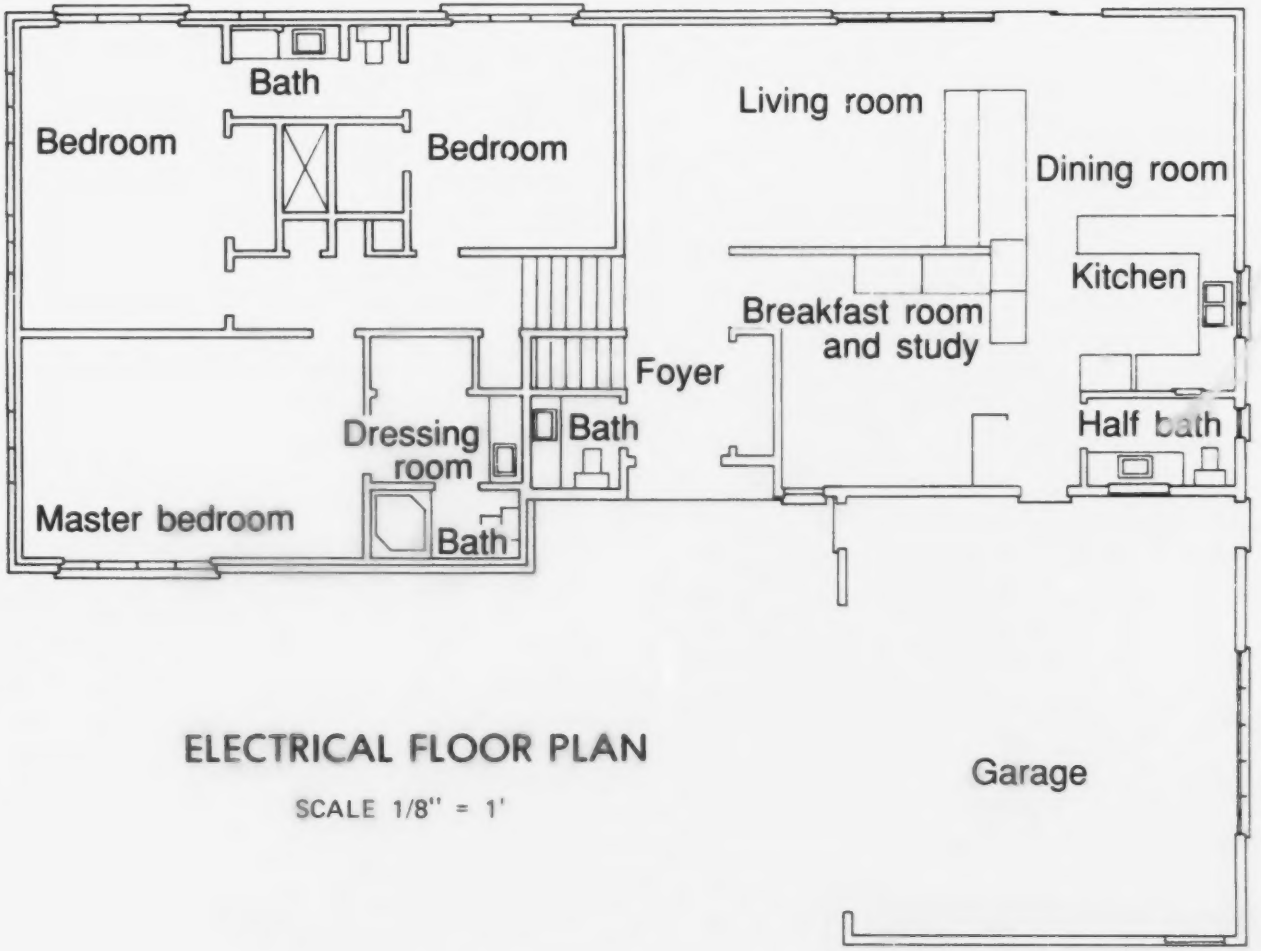


Electrical Floor Plan
Scale 1/8" = 1'

ELECTRICAL LAYOUT
UNIT III

ASSIGNMENT SHEET #1 — LOCATE RECEPTACLE, SWITCH, AND LIGHTING OUTLETS ALONG A FLOOR LINE AND THE CEILING ON A FLOOR PLAN

Using appropriate floor plan symbols, locate the minimum required receptacle switch and lighting outlets along the floor line and in the ceiling on the plan on the following page.



ELECTRICAL FLOOR PLAN

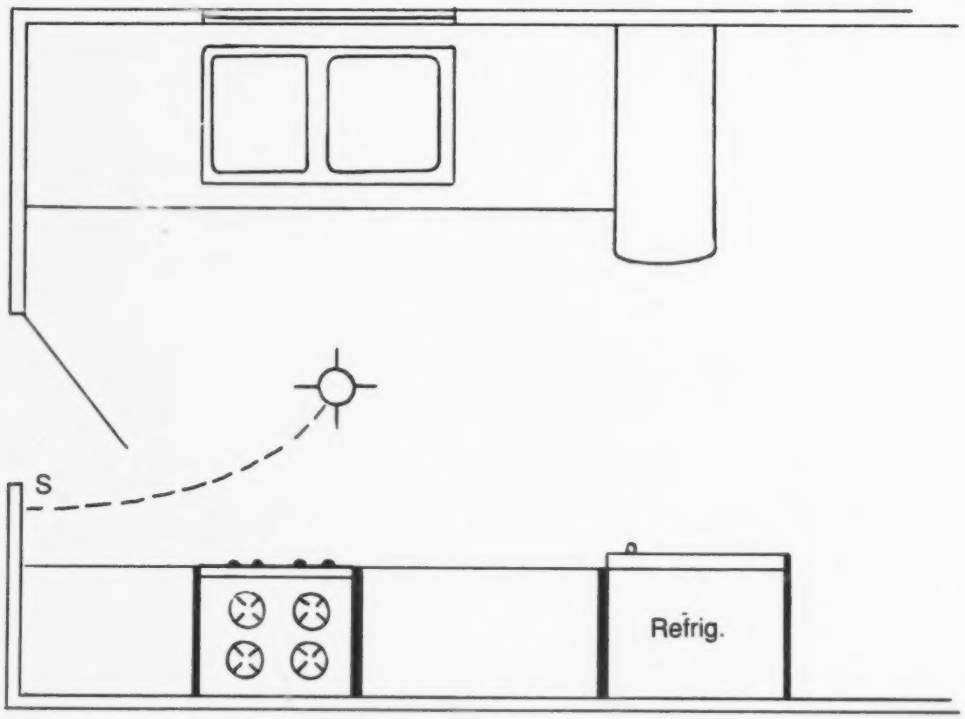
SCALE 1/8" = 1'

ASSIGNMENT SHEET #1

ELECTRICAL LAYOUT
UNIT III

ASSIGNMENT SHEET #2 — LOCATE RECEPTACLE OUTLETS ALONG KITCHEN COUNTERS ON A FLOOR PLAN

Using appropriate symbols, locate the minimum required receptacle outlets along the cabinet spaces in the print below.



ELECTRICAL LAYOUT
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheets #1 and #2

Evaluated to the satisfaction of the instructor

ELECTRICAL LAYOUT
UNIT III

JOB SHEET #1 — INSTALL A DEVICE BOX WHEN GIVEN CABINET HEIGHT AND WALL COVERING

Locate a device box in a backsplash behind a 36" high counter. The hanging cabinets start 18" from the counter top. The wall will be covered with 1/2" plasterboard.

I. Tools and equipment

A. Rule

B. Device box

C. Hammer

D. Nails

(NOTE: Some device boxes have nails already attached to the box. If so, no other nails are necessary.

E. Stud wall

(NOTE: This can be in a new house or a shop mock-up of an unfinished wall with studs exposed.)

F. Safety glasses

G. Pencil

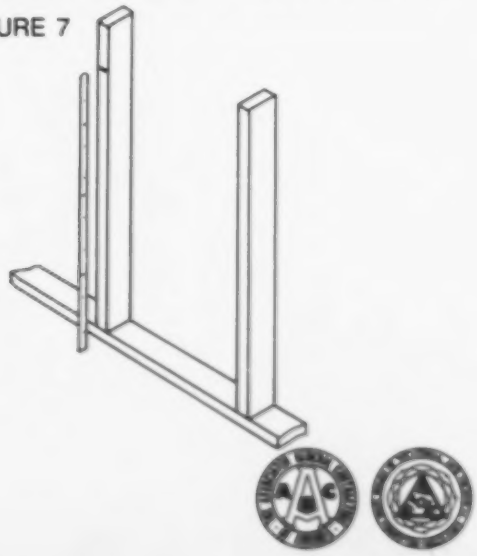
II. Procedure

A. Put on safety glasses

B. Determine box height and mark the stud for your box center (Figure 7)

(NOTE: In this job 45" will be acceptable.)

FIGURE 7



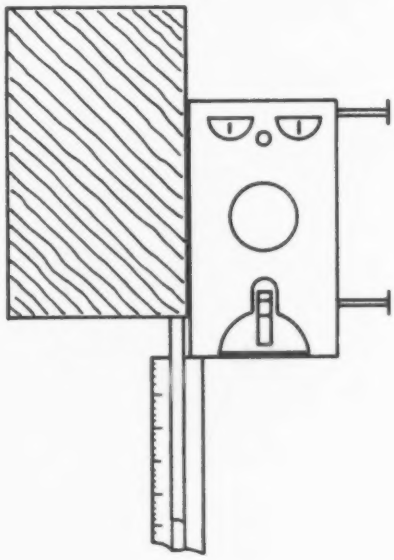
JOB SHEET #1

C. Determine appropriate box set out for wall covering specified.

(NOTE: In this instance for a noncombustible wall, set out is between one quarter and one-half inch.)

D. Locate box on center with correct set out (Figure 8)

FIGURE 8



E. Drive nails in to secure box

F. Check set out again

G. Clean work area and store tools properly

ELECTRICAL LAYOUT
UNIT III

JOB SHEET #2 — INSTALL A LIGHTING OUTLET BOX WHEN GIVEN WALL COVERING THICKNESS

I. Tools and equipment

(NOTE: The lighting outlet box is to be installed in a wall to be covered with 1/2" drywall.)

A. Rule

B. 4" octagon box

(NOTE: Any type lighting outlet box can be used for this installation.)

C. Hammer

D. Bar hanger

(NOTE: Bar hangers come in various lengths. You need to have a hanger that will fit between your studs.)

E. Nails

F. Stud wall

G. Safety glasses

H. Pencil

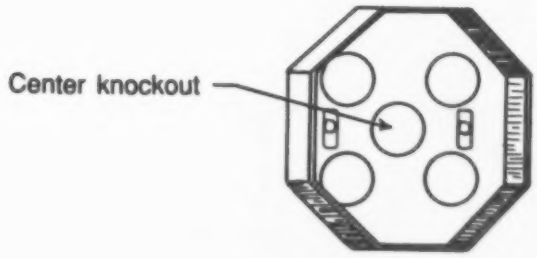
II. Procedure

(NOTE: The lighting outlet box is to be installed in a wall to be covered with 1/2" drywall.)

A. Put on safety glasses

B. Remove center knockout from the back of box (Figure 9)

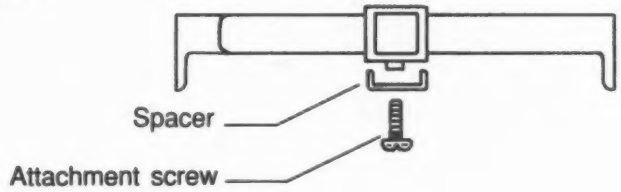
FIGURE 9



JOB SHEET #2

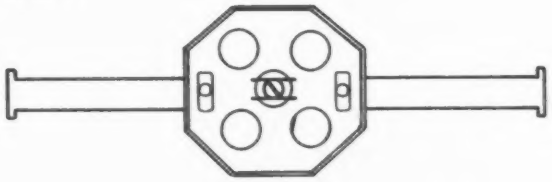
C. Remove attachment screw and spacer from bar hanger (Figure 10)

FIGURE 10



D. Mount box on the bar hanger and secure it loosely with spacer and attachment screw (Figure 11)

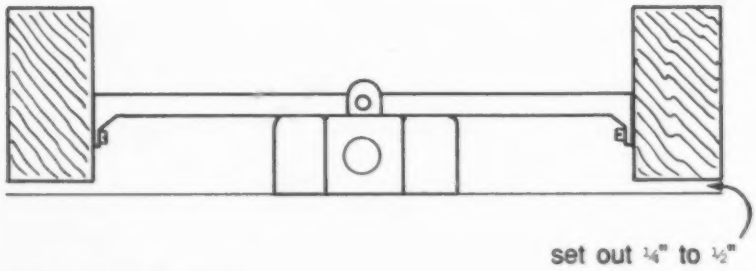
FIGURE 11



E. Place bar and box between stud and check set out (Figure 12)

(NOTE: Set out should be between 1/4" and 1/2".)

FIGURE 12



F. Nail hanger in place

G. Check set out again

H. Clean work area and store tools properly

ELECTRICAL LAYOUT
UNIT III

JOB SHEET #3 — INSTALL A BOX WITH DRYWALL GRIPS IN A DRYWALL WALL

I. Tools and equipment

A. Drywall wall

B. Switch box with plaster ears and drywall grips

(NOTE: Several forms of attaching devices are made for securing boxes to drywall.)

C. Pouch tools

D. 1/2" drill

E. Brace or drill motor and cord

F. Pencil

G. Keyhole saw

H. Safety glasses

I. Drop cloth

J. Utility knife

II. Procedure

(NOTE: Be sure that you are going to be able to get a cable to where the box is to be cut in before starting.)

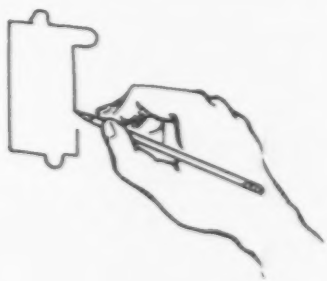
A. Put on safety glasses

B. Mark box height on wall

C. Pencil around the box (Figure 13)

(NOTE: Tap along the wall listening for hollow spaces or use a stud finder to make sure that a stud will not be in the cut out for the box.)

FIGURE 13

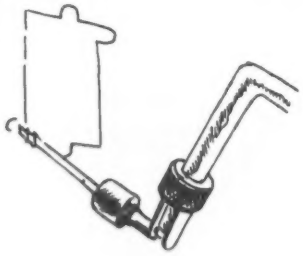


JOB SHEET #3

D. Place drop cloth below work area

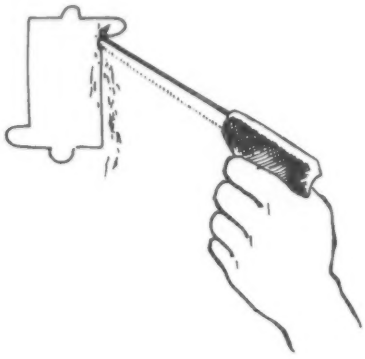
E. Drill holes in two of the corners (Figure 14)

FIGURE 14



F. Saw along drawn line (Figure 15)

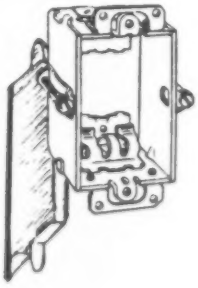
FIGURE 15



G. Fit box into opening (Figure 16)

(NOTE: You may need to do some trimming. The drywall will chalk white places on the box in areas where trimming is needed.)

FIGURE 16



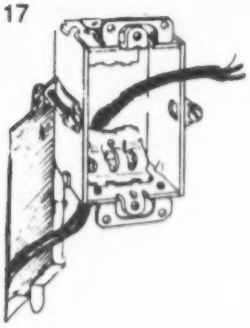
JOB SHEET #3

H. Remove box

I. Insert conductors

J. Replace box in opening (Figure 17)

FIGURE 17



K. Tighten screw to secure box

L. Pick up drop cloth

M. Clean work area and store tools properly

ELECTRICAL LAYOUT
UNIT III

JOB SHEET #4 — SECURE A BOX WITH DRYWALL SUPPORTS (BOXTINS)

I. Tools and materials

(NOTE: This job sheet deals only with the securing of boxes after the cable has been run and the opening cut.)

A. Switch box with ears

B. Drywall hangers

C. Opening in dry wall

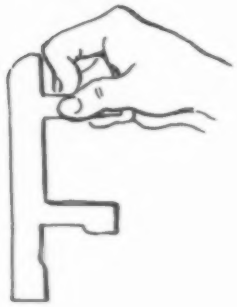
D. Line technician's pliers

II. Procedure

A. Place box in opening

B. Grip hanger in one hand (Figure 18)

FIGURE 18



C. Insert bottom of hanger beside box (Figure 19)

FIGURE 19

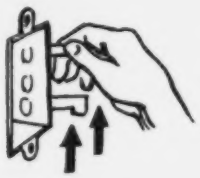
JOB SHEET #4

D. Push top of hanger in (Figure 20)

FIGURE 20

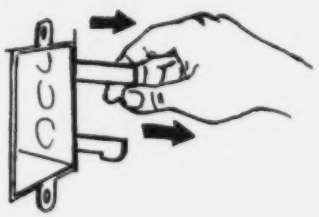
E. Raise hanger about 1/2" (Figure 21)

FIGURE 21



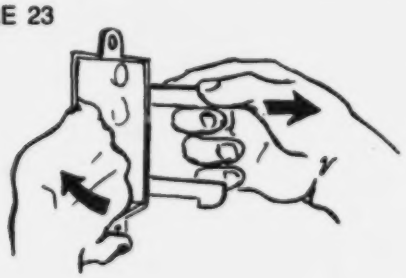
F. Apply outward pressure on hanger (Figure 22)

FIGURE 22



G. Put inward pressure on box with other hand (Figure 23)

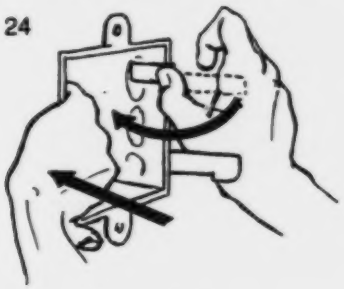
FIGURE 23



JOB SHEET #4

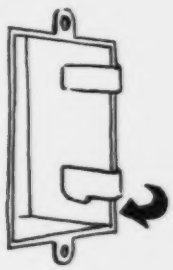
H. Bend tang over to secure box (Figure 24)

FIGURE 24



I. Bend other tang (Figure 25)

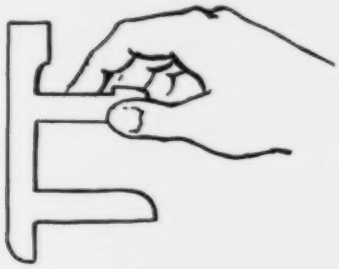
FIGURE 25



J. Grasp other hanger (Figure 26)

(NOTE: The hanger should be inserted with the long spine in the opposite direction of the first.)

FIGURE 26

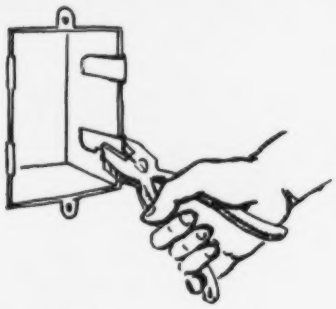


K. Secure in wall using steps "C" through "I."

JOB SHEET #4

L. Pinch tangs with line technician's pliers (Figure 27)

FIGURE 27



M. Have instructor evaluate

N. Clean work area and store tools properly

ELECTRICAL LAYOUT
UNIT III

JOB SHEET #5 — INSTALL A BOX IN A CONCRETE BLOCK WALL

I. Tools and equipment

A. Pouch tools

B. Concrete block wall

C. Concrete chisel

D. Switch box with ears

E. Pencil

F. Mortar

(NOTE: The mortar can be a commercial pre-mix or sand and cement mixture you blend yourself.)

G. Wood scraps

H. Safety glasses

II. Procedure

(NOTE: Be sure you will be able to get a cable to where the box will be cut in before starting.)

A. Put on safety glasses

B. Mark approximate box height

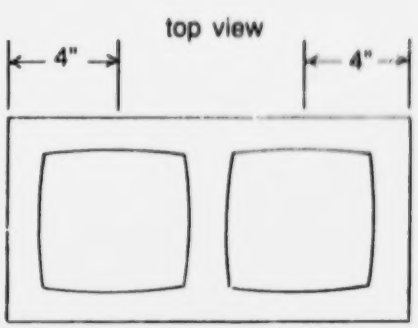
(NOTE: Make your mark in a mortar joint at the top or bottom edge of a block.)

C. Pencil around box

(NOTE: Make sure your box will be centered in a hollow space in the block. Four inches from either end should be a hollow space on an 8" x 8" x 16" block.)

EXAMPLE:

FIGURE 28

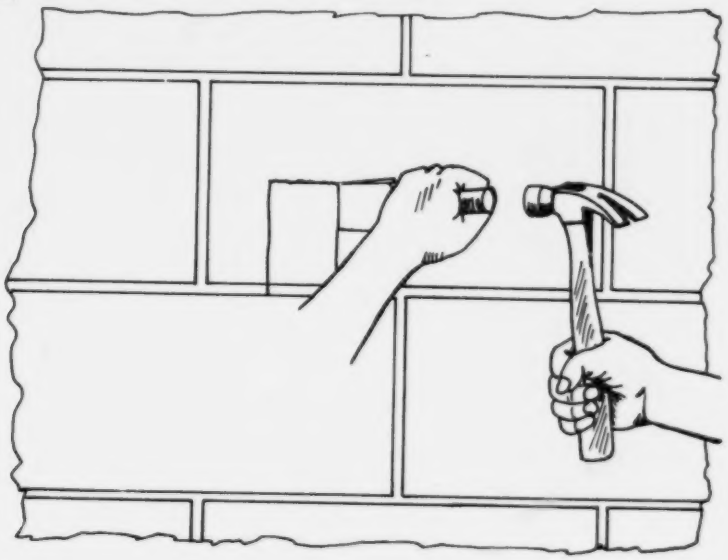


JOB SHEET #5

D. Tap chisel along pencil lines with hammer (Figure 29)

(NOTE: This should be done until a groove approximately one sixteenth of an inch deep replaces your penciled outline.)

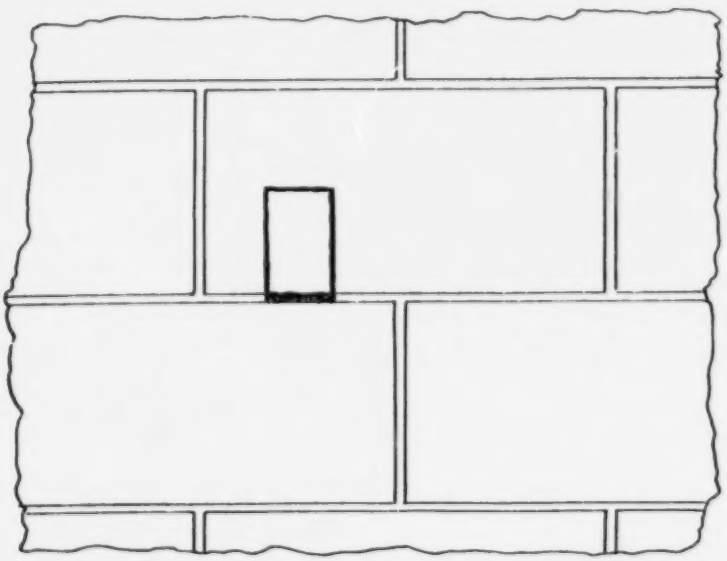
FIGURE 29



E. Knock mortar out along box outline (Figure 30)

(NOTE: If mortar is difficult to remove it can be drilled out.)

FIGURE 30

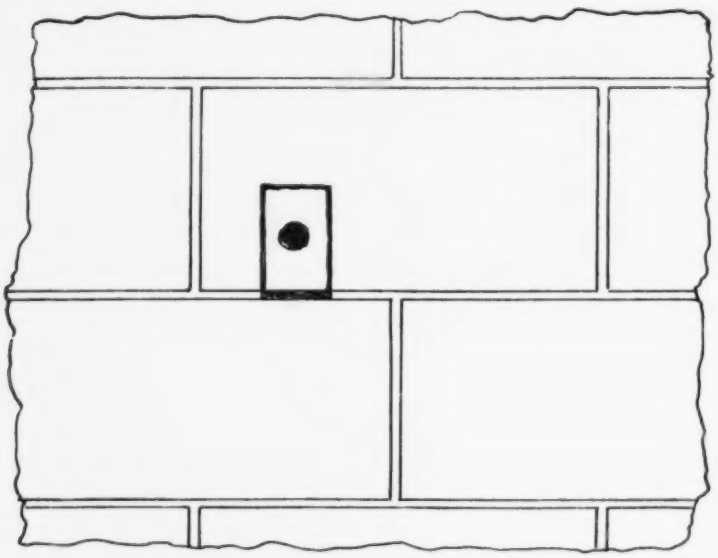


JOB SHEET #5

F. Tap center of box outline with hammer (Figure 31)

(NOTE: After several taps a hole will form.)

FIGURE 31



G. Gently tap from center hole towards the grooved box outline

(NOTE: The block should crack off at the groove. Don't get in a hurry. Slowly work around the groove until the opening is formed.)

H. Fit box into opening

(NOTE: The hole may have to be dressed with the chisel until the box fits.)

I. Remove box

J. Install cable in box

(NOTE: You may have to enter the back of the box; in this event you'll need a 3/8" cable clamp.)

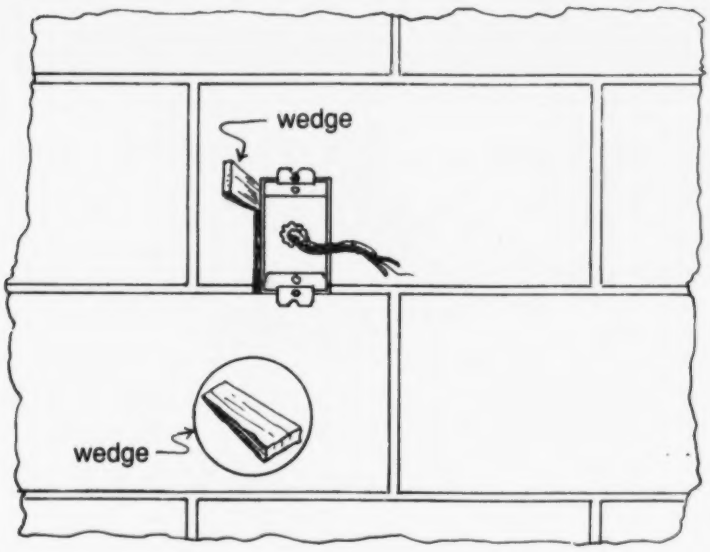
K. Reinstall box in opening

JOB SHEET #5

L. Secure box with narrow wood wedges (Figure 32)

(NOTE: The wedges can be made by chipping at the end of a two-by-four with your hammer claws. Put one wedge at the top and one at the bottom in opposite corners.)

FIGURE 32



M. Flush off wood securing wedges

(NOTE: Even if box seems secure you must use mortar or construction adhesive to finish the process.)

N. Mix up small amount of mortar

O. Force mortar between box and opening in block

P. Smooth out excess mortar

Q. Clean work area and store tools properly

ELECTRICAL LAYOUT
UNIT III

JOB SHEET #6 — INSTALL A BOX IN A CEILING WITH AN ACCESSIBLE ATTIC

I. Tools and equipment

A. Pouch tools

B. Keyhole saw

C. Octagon box

D. Bar hanger

E. Pencil

F. Drop cloth

G. Step ladder

(NOTE: Remember to be safety-conscious when working at all times, and remember the rules for ladder use.)

H. Safety glasses

I. 1/2" drill

J. Brace or drill motor and cord

K. Two roofing or drywall nails

L. Trouble light and bulb

II. Procedure

(NOTE: Be sure you can get a cable to where you are going to cut the box in.)

A. Put on safety glasses

B. Set up ladder

C. Place drop cloth under work area

D. Mark box location on ceiling

E. Pencil around the box

(NOTE: Be sure there is not a ceiling joist above where you plan on cutting the box in.)

F. Drill a hole in the corner of box outline

G. Saw out the box opening

JOB SHEET #6

(NOTE: If the ceiling is lath, chip the plaster off inside your outline before you saw the lath.)

H. Attach bar to box (Figure 33)

(NOTE: Reverse the bar so the nail slots are upward for easy nailing.)

FIGURE 33

I. Move ladder to attic access hole

J. Plug in drop light

K. Go into attic with pouch tools, nails, box, and trouble light

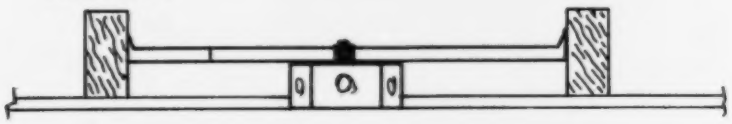
L. Walk on ceiling joists over to box opening

M. Position box in hole

N. Nail box between joists (Figure 34)

(NOTE: Be sure box is flush with ceiling.)

FIGURE 34



O. Insert cable in box

P. Gather tools and light

Q. Get down from attic

R. Reposition ladder

S. Tighten cable clamp and box support screw

T. Pick up drop cloth

U. Clean work area and store tools properly

ELECTRICAL LAYOUT
UNIT III

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with electrical layout. Write the correct numbers in the blanks.

_____a.	Design of parts in a pattern according to a scheme	1.	Parallel circuit
_____b.	Drawing that shows arrangement and relation to parts	2.	Overcurrent device
_____c.	Complete path for current to flow from the source through the load and back to the source	3.	Diagram
_____d.	Electrical circuit with all loads installed across circuit conductors	4.	Flush
_____e.	Electrical circuit with all loads installed in a single path	5.	Series circuit
_____f.	Measure of the potential difference between conductors in a circuit	6.	Schematic
_____g.	Opposition to electron flow in a conductor or circuit	7.	Resistance
_____h.	Current-limiting element in a circuit	8.	Box setout
_____i.	Distance that the box extends past the stud	9.	Circuit
_____j.	Even with the surface	10.	Voltage
_____k.	Grounded fault circuit interrupter	11.	GFCI

TEST

2. Match to their correct names the electrical schematic symbols on the right. Write the correct numbers in the blanks.

_____a. Contacts

1) Normally open

2) Normally closed

_____b. Fixed bimetal thermostat

_____c. Ground connection

_____d. Single pole single throw switch

_____e. Single phase motor

_____f. Thermostat

1) Closes on rise

2) Opens on rise

_____g. Transformer

_____h. Fuse

_____i. Resistor or load

1) Fixed

2) Variable

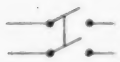
_____j. Wire connection

_____k. Three way switch

_____l. Wire crossover

_____m. Double pole single throw switch

_____n. Four way switch

1. 

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

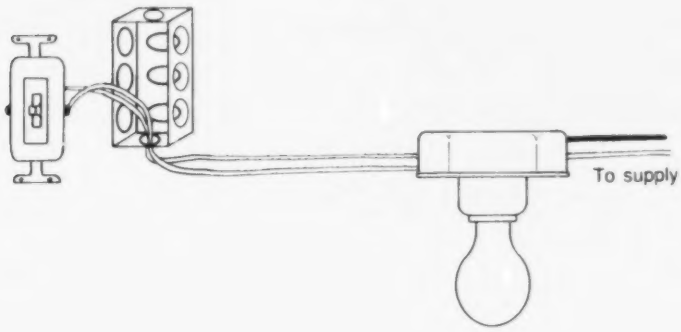
12.

13.

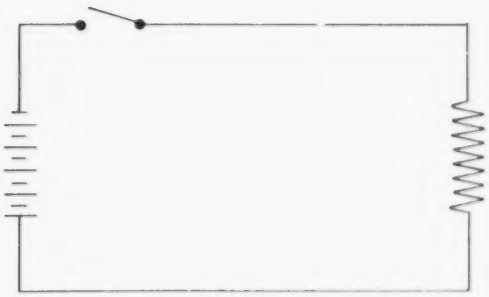
14.

TEST

3. Distinguish between the following wiring diagram and schematic by writing diagram or schematic in the appropriate blank.



a. _____



b. _____

TEST

4. Draw a schematic of a simple series circuit.

5. State four rules for series circuits.

   a. _____

   _____

   b. _____

   _____

   c. _____

   _____

   d. _____

   _____

6. List three common applications for series connections.

   a. _____

   b. _____

   c. _____

TEST

7. Draw a schematic of a simple parallel circuit.

8. State four rules for parallel circuits.

   a. _____

   _____

   b. _____ _____

   _____

   c. _____

   _____

   d. _____

   _____

9. List two common applications of parallel circuits.

   a. _____

   b. _____

TEST

10. Select from the following list good planning techniques when placing boxes on plans. Write an "X" in the correct blanks.

    _____a. Put outlet boxes high enough so small children cannot reach them

    _____b. Put boxes in even groups if possible

    _____c. Place outside lighting outlets low enough for any fixture

    _____d. Keep spacing even where possible

    _____e. Be sure all grouped boxes are in an even vertical line

    _____f. Check door swing so switches are not behind doors

11. List accepted heights for boxes in various locations.

    a. Above kitchen counter tops — _____

    b. Above bathroom cabinets — _____

    c. Receptacles along floor line — _____

    d. Wall switches — _____

(NOTE: Test questions 12 through 14 list the assignment and job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

12. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a floor plan

13. Locate receptacle outlets along kitchen counters on a floor plan

14. Demonstrate the ability to:

    a. Install a device box when given cabinet height and wall covering

    b. Install a lighting outlet box when given wall covering thickness

    c. Install a box with drywall grips in a drywall wall

    d. Secure a box with drywall supports (Boxtins)

    e. Install a box in a concrete block wall

    f. Install a box in a ceiling with an accessible attic

ELECTRICAL LAYOUT
UNIT III

ANSWERS TO TEST

1.

a.	6	e.	5	i.	8
b.	3	f.	10	j.	4
c.	9	g.	7	k.	11
d.	1	h.	2		

2.

a.	5	e.	3	i.	8	m.	1
b.	7	f.	2	j.	11	n.	14
c.	9	g.	4	k.	13		
d.	12	h.	6	l.	10		

3. a. Diagram
   b. Schematic

4. Evaluated to the satisfaction of the instructor

5. Answer should include the following:

   a. The sum of the voltages across the individual components equal the voltage applied to the circuit
   b. The largest voltage drop occurs in the component with the highest resistance
   c. The sum of the resistance of the components equals the total resistance
   d. Current is the same through all components of a series circuit

6. Answer should include:

   a. Switches
   b. Overcurrent devices
   c. Thermal protection devices

7. Evaluated to the satisfaction of the instructor

8. Answer should include the following:

   a. Total current equals the sum of all currents of the branches
   b. Voltage is the same across all branches
   c. Total resistance in a parallel circuit is always less than the individual branches
   d. Total power consumed in a parallel circuit equals the sum of the power consumed in the branches

ANSWERS TO TEST

9. Answer should include:

   a. Supplying receptacle outlets
   b. Supplying light fixtures

10. b, c, d, f

11. a. 45" to box center
    b. 40" to box center
    c. 12" to box center
    d. 48" to box center

12. Evaluated to the satisfaction of the instructor

13. Evaluated to the satisfaction of the instructor

14. Performance skills evaluated to the satisfaction of the instructor

ELECTRICAL BASIC SKILLS
UNIT IV

UNIT OBJECTIVE

After completing this unit, the student should be able to list general rules for electrical installations as well as agencies that can set standards for these installations and should be able to state basic electrical safety practices. The student should also be able to perform various wiring operations. The student will show this ability by completing job sheets and unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. List rules for electrical installations.
2. State basic electrical safety practices.
3. Match terms associated with switching situations to their correct definitions.
4. List requirements for terminal identification.
5. List steps for grounding devices and boxes.
6. Identify parts of various switching circuits.
7. Match terms associated with receptacle outlets to their correct definitions.
8. Identify parts of a duplex grounding type receptacle.
9. Identify parts of the equipment grounding circuit.
10. List NEC requirements pertaining to receptacles.
11. Match terms associated with service installations to their correct definitions.
12. Match the required clearances of service drop conductors to various construction locations.
13. State the maximum number of service entrance disconnects.
14. List facts that should be known before the service installation is started.
15. Identify the parts of a service entrance.
16. Discuss briefly the various types of grounding electrodes.
17. Discuss briefly grounding electrode conductor installations and sizes.

SPECIFIC OBJECTIVES

18. Demonstrate the ability to:

    a. Wire a single pole switch controlling a single lighting outlet with the supply line entering the switch box.

    b. Wire a single pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box.

    c. Wire a three-way switching situation with the supply entering a single lighting outlet.

    d. Install a duplex grounding type receptacle.

    e. Install a multi-circuit, split-wired duplex grounding type receptacle.

    f. Wire a switch controlled, split-wired receptacle.

    g. Wire a receptacle fed from a lighting outlet through a single pole switch.

    h. Install an overhead raceway with service entrance conductors to a meter base.

    i. Connect meter base assembly to load center or panel.

    j. Install plates on devices.

ELECTRICAL BASIC SKILLS
UNIT IV

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Supplement #1 — Effects of Amperes on the Human Body at 120 Volts, 60 Hertz (Cycle)

D. Information Sheet

E. Job Sheets

1. Job Sheet #1 — Wire a Single Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Switch Box

2. Job Sheet #2 — Wire a Single Pole Switch Controlling a Single Lighting Outlet with the Supply Line Entering the Lighting Outlet Box

3. Job Sheet #3 — Wire a Three-Way Switching Situation with the Supply Entering a Single Lighting Outlet

4. Job Sheet #4 — Install a Duplex Grounding Type Receptacle

5. Job Sheet #5 — Install a Multi-Circuit, Split-Wired Duplex Grounding Type Receptacle

6. Job Sheet #6 — Wire a Switch Controlled, Split-Wired Receptacle

7. Job Sheet #7 — Wire a Receptacle Fed from a Lighting Outlet Through a Single Pole Switch

8. Job Sheet #8 — Install an Overhead Raceway with Service Entrance Conductors to a Meter Base

9. Job Sheet #9 — Connect Meter Base Assembly to Load Center or Panel

10. Job Sheet #10 — Install Plates on Devices

F. Test

G. Answers to test

SUGGESTED ACTIVITIES

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Obtain tools, equipment, and materials necessary to perform procedures outlined in the job sheets.

2. Obtain safety signs and posters to display in class.

(NOTE: Various safety educational material and filmstrips are available from Underwriters Laboratories, Inc., Public Information and Education Services, 207 East Ohio Street, Chicago, IL 60611.)

3. Books and publications

a. Up-to-date copy of *National Electrical Code*

b. *Control of Electrical Shock Hazards*. Bulletin 216 from U.S. Department of Labor

4. Copies of electrical codes

a. Local and state

b. Federal

5. Competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Make copies of the handout to pass out to the students.

D. Introduce unit to students.

- Stress the importance of safety, particularly when working with live circuits

E. Provide students with objective sheet.

F. Discuss unit and specific objectives.

G. Provide students with information and job sheets.

SUGGESTED ACTIVITIES

H. Discuss information and job sheets.

1. Use Information Sheet, Sections I and II, to discuss rules and safety practices pertaining to electrical installations.
   - Show any safety films that may be available.
   - Discuss safety and code procedures with students.
   - Discuss local and state codes.
   - Consult with local utility company about their requirements.
2. Use Information Sheet, Section III, to discuss terms and definitions associated with switching situations.
   - Use the chalkboard and actual items to supplement your explanation of the various terms.
   - Explain how knowing the terms and definitions will help the student understand and grasp the importance of this unit.
3. Use Information Sheet, Section IV, to discuss requirements for terminal identification.
   - Review Article 200 in the NEC.
   - Show students samples of grounding terminals, traveler terminals, neutral conductors and terminals and underground conductors to help reinforce your discussion.
4. Use Information Sheet, Section V, to discuss steps for grounding devices and boxes.
   - Show students illustrations of the grounding devices and boxes as shown in Figure #1.
   - Point out how the grounding conductors are grouped and how the grounding terminals on the devices are bonded to the metal boxes.
   - Discuss the importance and safety features involved.
5. Use Information Sheet, Section VI, to discus parts of various switching circuits.
   - Put together a mock-up of the different switching circuits; have students identify the different parts then discuss how they go together and how they are used.
   - Demonstrate procedures for Job Sheets #1, #2, and #3, then have students complete these three job sheets.

SUGGESTED ACTIVITIES

6. Use Information Sheet, Section VII, to discuss terms and definitions associated with receptacle outlets.

   - Display samples of actual items to supplement your discussion on receptacle outlets.
   - Explain how knowing the terms and definitions will help the student better understand this part of the unit.

7. Use Information Sheet, Sections VIII, IX, and X, to discuss parts of a duplex grounding type receptacle, parts of the equipment grounding circuit, and NEC requirements pertaining to receptacles.

   - Display a sample of a grounded duplex receptacle and a sample of an ungrounded duplex receptacle; have students identify the different parts then discuss the differences in the two receptacles.
   - Display a mock-up of the equipment grounding circuit.
   - Have students identify parts of this circuit; demonstrate the procedures for putting this together.
   - Discuss parts of the equipment grounding circuit.
   - Discuss NEC requirements and codes pertaining to receptacles.
   - Demonstrate procedures for Job Sheets #4, #5, #6, and #7; have students demonstrate these procedures.
   - Have students complete Job Sheets #4 through #7.

8. Use Information Sheet, Section XI, to discuss terms and definitions associated with service installations.

   - Use the chalkboard and actual items to supplement your discussion of the various terms.
   - Relate these terms to an actual service installation and to Article 100 in the NEC.
   - Explain how knowing the terms and definitions will help the student understand and grasp the importance of this section of the unit.

9. Use Information Sheet, Sections XII through XV, to discuss parts of a service entrance, facts that should be known before starting service installation, required clearances of service drop conductors and maximum number of service entrance disconnects pertaining to construction locations.

   - Take students on a field trip where they can see a completed service entrance, then take them to a job site where a service entrance is being installed so students can see how the whole project goes together.

SUGGESTED ACTIVITIES

- Have students identify parts of a service entrance.
- Discuss local and state codes and requirements.
- Refer to Article 230 of NEC to compare clearances for service drop connectors and maximum number of service entrance disconnects with the local and state codes and with the local utility company.
- Demonstrate proper procedures for Job Sheets #8 and #9.
- Stress the importance of safety and safe practices.
- Allow students to demonstrate procedures for Job Sheets #8 and #9.
- Have students complete Job Sheets #8 and #9.

10. Use Information Sheet, Sections XVI and XVII, to discuss types and sizes of electrodes and grounding electrode conductor installations.
    - Check Article 250 of the NEC for further information on electrodes and grounding.
    - Take a tour around your building and have students point out the different grounding electrodes and grounding electrode conductors. Have students make a list of how many different sizes and types are used.
    - Discuss the purpose and the different methods used for grounding.
11. Have students complete Job Sheet #10.

I. Give test.

J. Critique test and discuss in class.

K. Reteach and retest as necessary.

L. Complete appropriate section of competency profiles.

III. Unit references

A. Calvin, Thomas S., *Maintaining the Lighting and Wiring System*. Athens, Georgia: American Association For Vocational Instructional Materials, 1974.

B. Taylor, Mark *Residential Wiring*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1978. Revised 1983.

ELECTRICAL BASIC SKILLS
UNIT IV

SUPPLEMENT #1 — EFFECTS OF AMPERES ON THE HUMAN BODY AT 120 VOLTS, 60 HERTZ (CYCLE)

.0005 or less amperes — No sensation

.0005 to .002 amperes — Threshold of perception

.002 to .010 amperes — Muscular contraction (mild to strong)

.005 to .025 amperes — Painful shock, inability to let go

.025 to more amperes — Violent muscular contraction

.050 to .200 amperes — Ventricular fibrillation (convulsive movement of the heart - fatal)

Over .100 amperes — Paralysis of breathing (apply artificial respiration immediately)

ELECTRICAL BASIC SKILLS
UNIT IV

INFORMATION SHEET

I. Rules for electrical installation

A. Always be safety conscious

B. Be sure all connections are secure and well insulated

C. Always be sure that overcurrent protection is matched to your conductor rating

D. Preform conductors before installing devices in boxes

E. Use appropriate tools

F. Always meet or exceed NEC and local code minimum installation requirements

II. Basic electrical safety practices

A. Never underestimate the danger of 110-volt AC circuits

(NOTE: More people die from 110-volt electrical shock than any other voltage. This is due mostly to a lack of respect.)

B. Watch out for electrical arcs; they can cause bad burns

C. Remember that mild shocks can cause personal injury or injury to others by your reaction

D. Never install equipment that will overload a circuit

E. Never bypass a fuse

F. Be sure all electrical lines carrying current are well insulated

G. Always check a circuit for voltage before servicing

H. Work on live circuits only when absolutely necessary

I. Use a neon test light or voltmeter to identify live circuits

J. Stand on dry surface when working with live circuits

K. Use only one hand if possible

L. Wear suitable insulated hand coverings

M. Never keep tools lying around live conductors

N. Return all tools to pouch when through working with them

INFORMATION SHEET

III. Terms and definitions associated with switching situations

A. **Device** — Unit of an electrical system which is intended to carry but not utilize electrical energy

B. **Cable clamp** — Piece of equipment used to secure cables

C. **Hertz** — Unit of frequency equal to one cycle per second

D. **Hickey** — Threaded nipple used for hanging fixtures

E. **NEC (National Electrical Code)** — Written articles whose purpose provides minimum standards for safe installations and practical safeguarding of persons and property from hazards arising from the use of electricity

F. **Return leg** — Conductor that carries electrical energy from the switch to the load

(NOTE: Terminology relating to these conductors may vary in the field.)

G. **Strap** — Metal strip which contains one or more devices

H. **Switch** — Device used to open or transfer circuit direction

I. **Switch leg** — Conductor that supplies electrical energy to a switch

J. **Switch loop** — Conductor between light and switch when supply enters the light

K. **Terminal** — Point of attachment for conductors

L. **Traveler** — Transfers conductors in a switching situation; used between 3-ways and 4-ways

M. **Volt** — Unit measure for electrical pressure

IV. Requirements for terminal identification

(NOTE: Requirements for terminal identification can be found in NEC Article 200. Single pole switches have no device terminal identification.)

A. All grounding terminals shall be green and hex-headed

B. Traveler terminals on three-way switches shall be the same color, and different from the controlling or common terminal

C. Neutral conductors and terminals shall be white, silver, or labeled with the word "white" or the letter "W"

D. Underground conductors are usually copper colored but could be any color other than those already designated

INFORMATION SHEET

V. Steps for grounding devices and boxes

A. Group and solidly connect all grounding conductors

B. Connection shall be made from the grounding conductors to a green hex head screw or other device to ground all metal boxes

C. Grounding terminals on devices shall be connected to metal boxes by a bonding jumper to metal boxes for flush installations

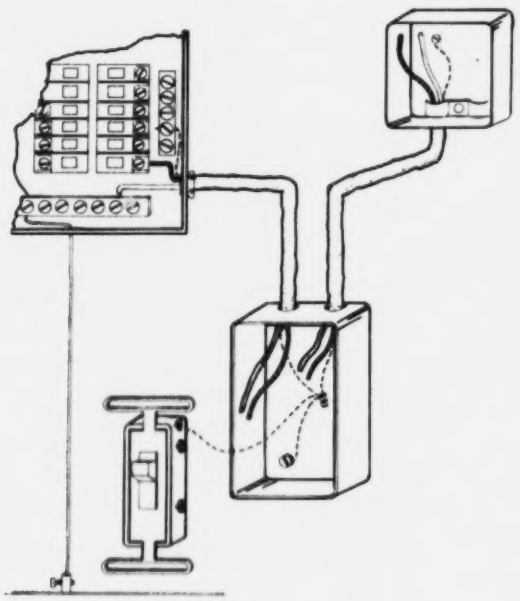
(NOTE: This connection shall be made in a manner that will allow for the removal of the device without breaking the continuity between the conductors and the box.)

D. On surface boxes the metal contact between the device and box shall serve as the grounding bond

E. In plastic boxes group the grounding conductors and connect them to the device grounding terminal

EXAMPLE:

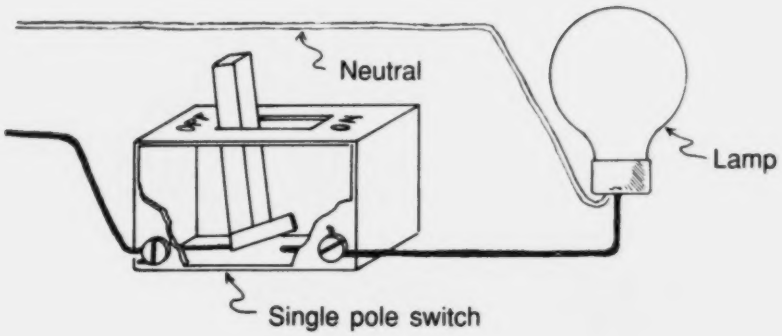
FIGURE 1

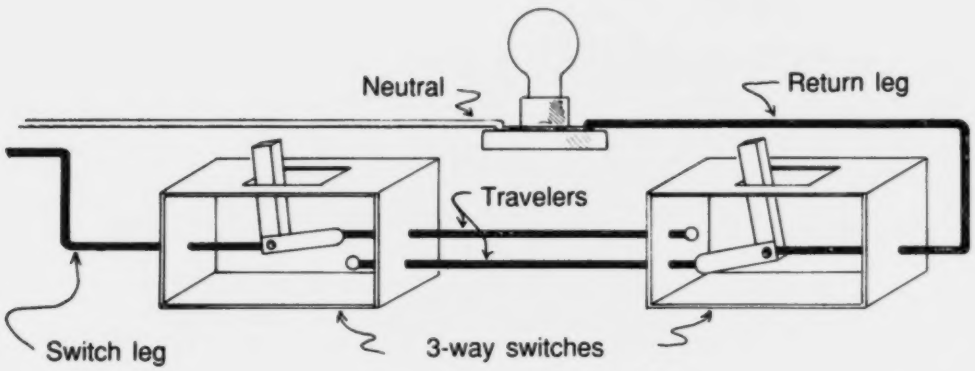


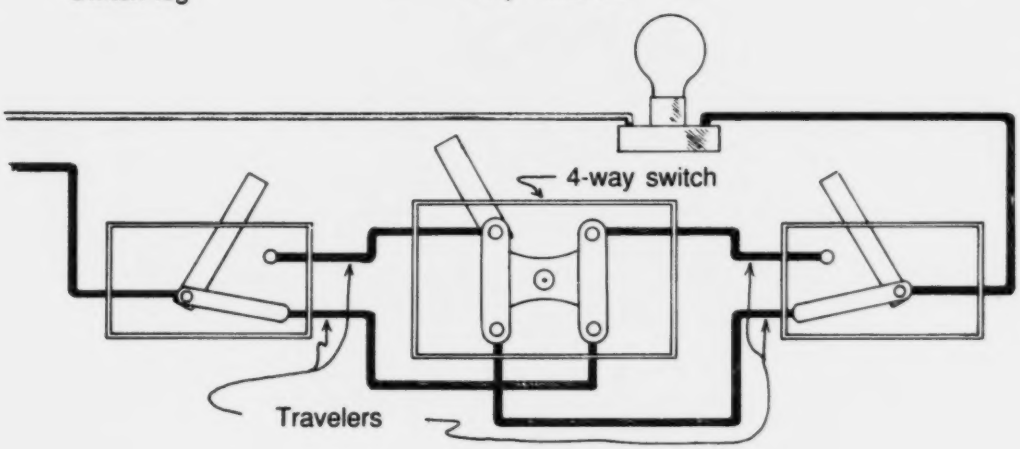
INFORMATION SHEET

VI. Parts of various switching circuits

FIGURE 2







INFORMATION SHEET

VII. Terms and definitions associated with receptacle outlets

A. **Poles** — Current carrying conductors, both grounded and ungrounded, on a receptacle

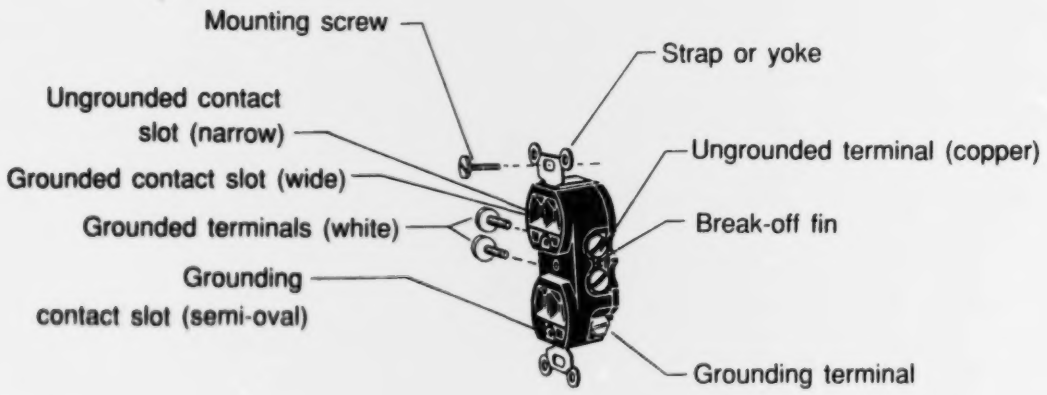
B. **Wires** — Current carrying conductors and grounding conductors

C. **Strap or yoke** — Metal strip containing one or more devices

D. **Multiple receptacle** — Single device with two or more receptacles

VIII. Parts of a duplex grounding type receptacle

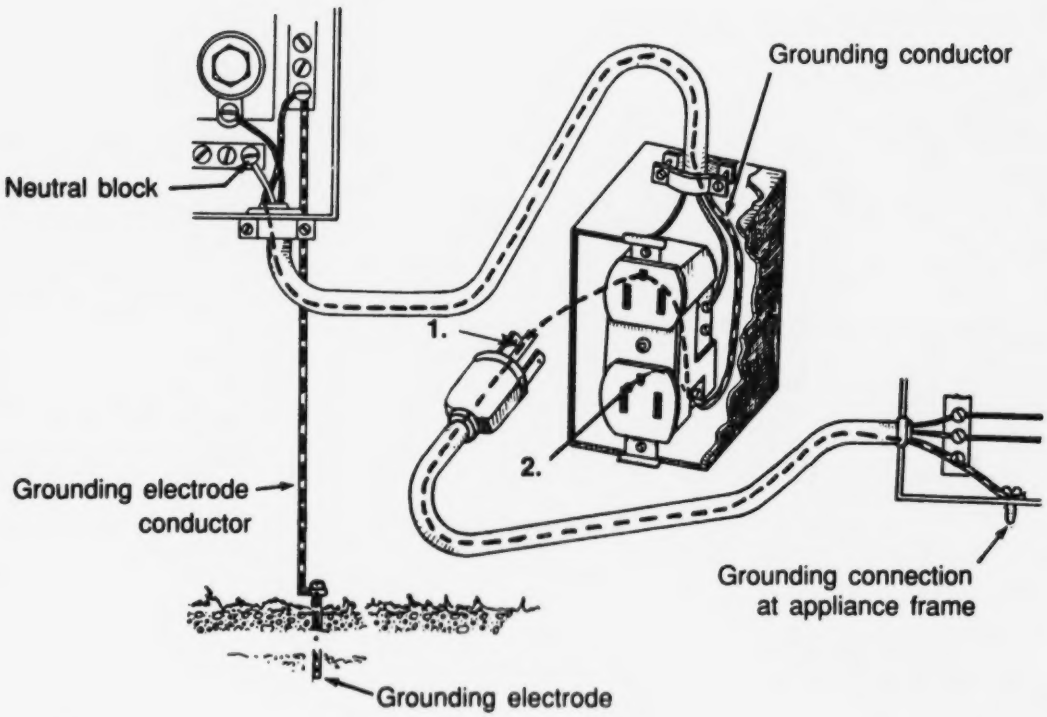
FIGURE 3



INFORMATION SHEET

IX. Parts of the equipment grounding circuit

FIGURE 4



1. Attachment cap grounding prong
2. Receptacle grounding slot

INFORMATION SHEET

X. NEC requirements pertaining to receptacles

A. Single receptacles on individual branch circuits must be rated at least equal to the branch circuit

B. Receptacles installed on 15 and 20 ampere branch circuits shall be of the grounding type

C. Where practical to get a source of ground, replacement receptacles for nongrounding receptacles shall be of the grounding type

(NOTE: When a grounding conductor is not present in the box a nongrounding receptacle can be used.)

XI. Terms and definitions associated with service installations

(NOTE: The majority of these definitions are from NEC Article 100.)

A. **Service** — Conductors and equipment for delivering energy from the electric supply system to the wiring system of the premises to be served

B. **Service cable** — Service conductors made up in the form of a cable

C. **Service conductors** — Supply conductors that extend from the street main or from transformers to the service equipment of the premises to be supplied

D. **Service drop** — Overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service entrance conductors at the building or other structure

E. **Service entrance conductors, underground system** — Service conductors between the terminals of the service equipment and the point of connection to the service lateral

F. **Service entrance conductors, overhead service** — Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop

G. **Service equipment** — Necessary equipment, usually consisting of a circuit breaker or fuses and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply

(NOTE: Overcurrent devices shall not be located in the vicinity of easily ignitable material such as in clothes closets.)

INFORMATION SHEET

H. **Service lateral** — Underground service conductors between the street main, including any risers at a pole or other structure, or from transformers and the first point of connection to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall

(NOTE: Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection will be considered to be the point of entrance of the service conductors into the building.)

I. **Service raceway** — Raceway that encloses the service entrance conductors

J. **Grounding electrode conductor** — Conductor used to connect the grounding electrode to the equipment grounding conductor and/or the grounded conductor of the circuit at the service

K. **Service mast** — Portion of a service raceway that extends through a roof or eave

L. **Roof-flashing** — Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage

XII. Required clearances of service drop conductors not in excess of 600 volts to various construction locations

(NOTE: NEC Article 230 deals with services.)

A. Over roofs — Not less than 8 feet from highest point except where the voltage between conductors does not exceed 600 volts and:

1. If the roof has a slope of not less than 4 inches in 12 inches, a 3 feet minimum is permitted on systems which do not exceed 300 volts between conductors.

2. If the conductors do not pass over more than 4 feet of overhang and are terminated at a through-the-roof raceway or support, an 18 inch minimum is permitted on systems which do not exceed 300 volts between conductors.

B. From ground vertically

1. 10 feet — At the electric service entrance to buildings, or at the drip loop of the building electric entrance, measured from final grade or other accessible surface only for service-drop cables supported on and cabled together with a grounded bare messenger and limited to 150 volts to ground.

2. 12 feet — For those areas listed in the 15 foot classification when the voltage is limited to 300 volts to the ground.

3. 15 feet — Over residential property, driveways, and those commercial areas not subject to truck traffic.

4. 18 feet — Over public streets, alleys, roads, parking areas subject to truck traffic, driveways on other than residential property, and other land traversed by vehicles such as cultivated, grazing, forest, and orchards.

XIII. Maximum number of service entrance disconnects

A. Not more than six switches in single enclosure or grouped on a switchboard

B. Not more than six circuit breakers in single enclosure or grouped on a switchboard

(NOTE: NEC Article 230 deals with services. Where residence requires more than six circuits, a main breaker is usually used.)

XIV. Facts that should be known before service installation is started

A. Determine if underground or overhead service will be used

B. Amount of voltage and amperage service needed

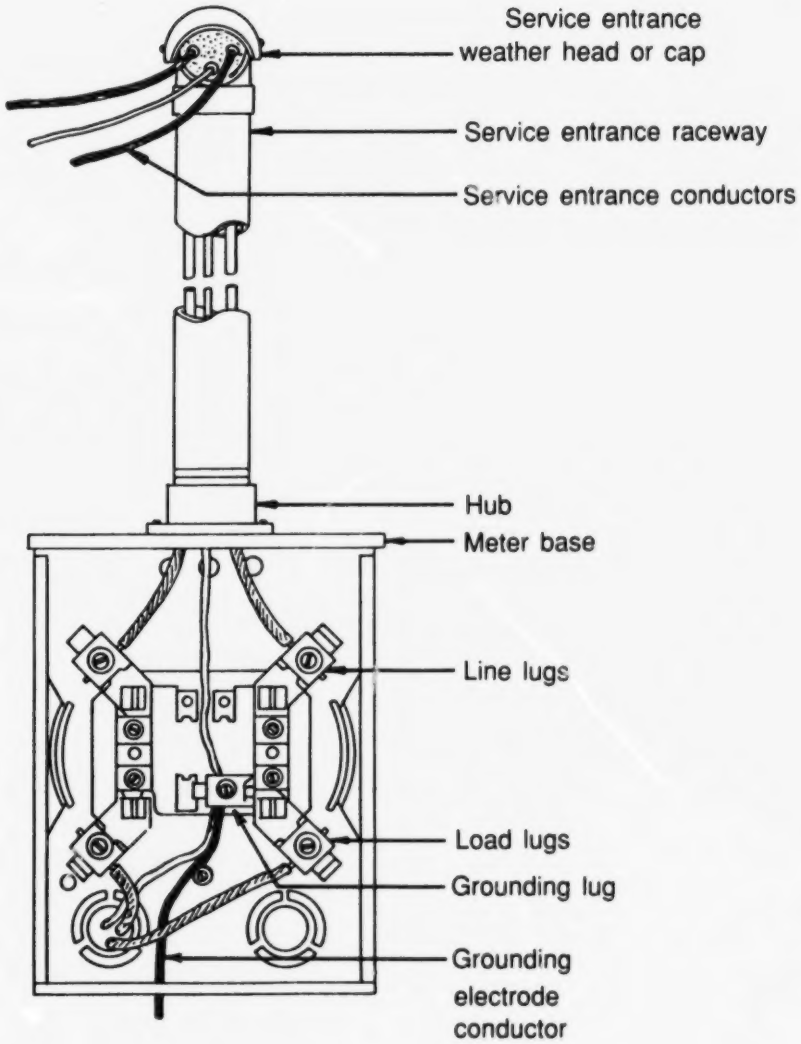
C. Location where service conductors will enter the building

D. Size of service equipment needed

INFORMATION SHEET

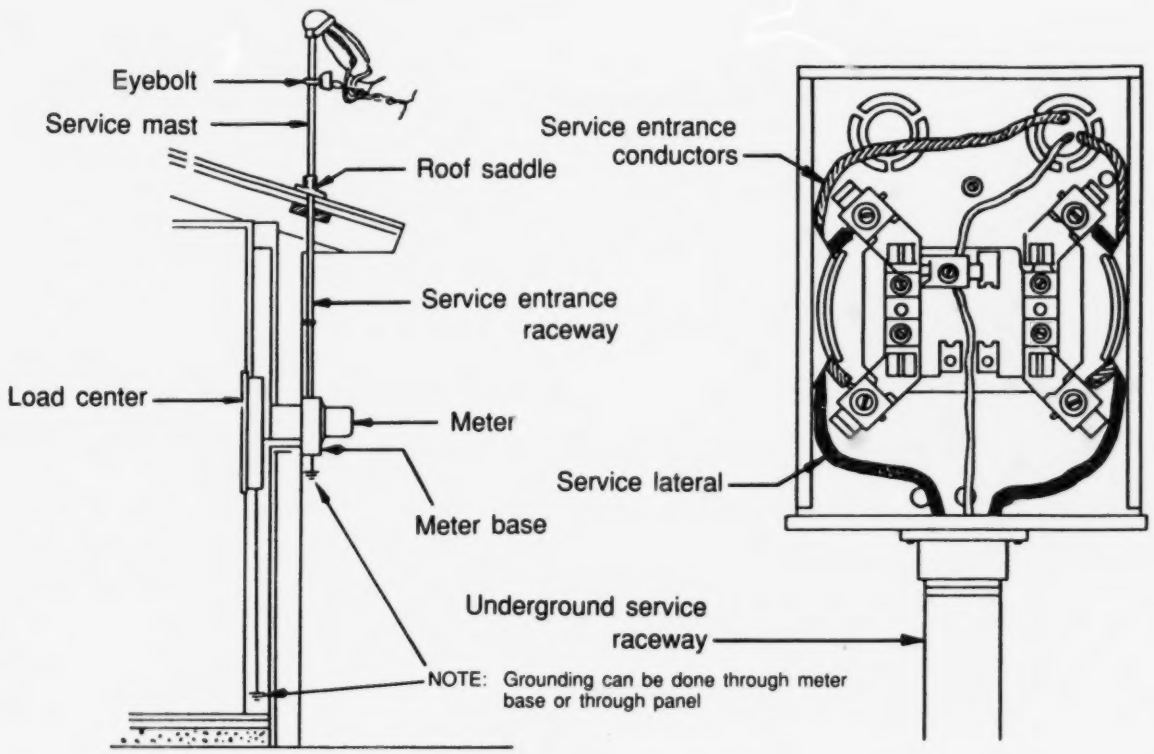
XV. Parts of a service entrance

FIGURE 5



INFORMATION SHEET

FIGURE 5 (Continued)



INFORMATION SHEET

XVI. Types of grounding electrodes

(NOTE: NEC Article 250 deals with grounding.)

A. Structural metal — Nearest available, effectively grounded structural metal member of the structure

B. Water pipe — Metal water pipe shall be used when available

(NOTE: The pipe should be in direct contact with earth for 10 feet or more and electrically continuous to the points of connection of the grounding electrode conductor and the bonding conductors.)

C. Job made electrodes

1. At least 20 feet of #4 or larger bare copper wire or 1/2-inch or larger steel reinforcing bar encased in at least 2 inches of concrete in footing

2. 8 foot lengths of:

a. 3/4-inch galvanized pipe

b. 5/8-inch iron or steel rod

c. 1/2-inch nonferrous rod (copper, brass, and other noncorrosive metals)

(NOTE: Drive electrode 8 feet deep; if electrode hits rock at less than 4 feet the electrode shall be buried in a trench.)

3. At least 20 feet of #2 bare copper, 2-1/2 feet under grade encircling the structure

XVII. Grounding electrode conductor installations and sizes

A. Conductors and enclosures shall be secured to the surface they follow

B. #6 or larger conductors

1. Must be in conduit if subjected to physical damage

2. If free of physical damage it may follow the surface of building if properly secured

3. Aluminum or copper clad aluminum cannot be used in contact with masonry or earth

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #1 — WIRE A SINGLE POLE SWITCH CONTROLLING A SINGLE LIGHTING OUTLET WITH THE SUPPLY LINE ENTERING THE SWITCH BOX

I. Tools and equipment

A. 12-2-G or 14-2-G NM cable

B. Device box

C. Octagon box

(NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors you will install.)

D. Staples

E. Single pole switch

F. Light socket

G. Bar hanger

(NOTE: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)

H. Stud wall or work board

I. 120v supply

(NOTE: The overcurrent supply should not exceed your conductors NEC capacity rating.)

J. 3/8" cable clamp

(NOTE: This fits a one-half inch knockout.)

K. 120v incandescent bulb

L. Wire connectors

(NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors or solder would also be acceptable in the trade.)

M. Two 16 penny nails

N. 2 drywall nails

O. Electrician's hammer

JOB SHEET #1

P. Long nose pliers

Q. Pocket knife

R. Wire strippers

S. Tool pouch

T. Drill motor or bit brace

U. 1/2" or larger wood bit

(NOTE: Hole should be large enough to safely accommodate cable.)

V. Extension cord

W. Safety glasses

X. Standard screwdriver

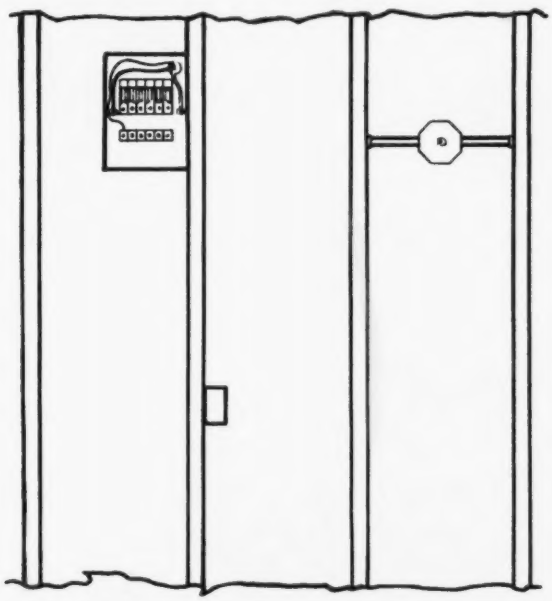
II. Procedure

A. Put on safety glasses

B. Mount boxes (Figure 6)

(NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)

FIGURE 6

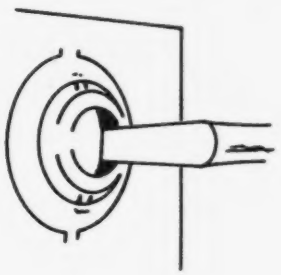


JOB SHEET #1

C. Remove a half-inch knockout from the panel

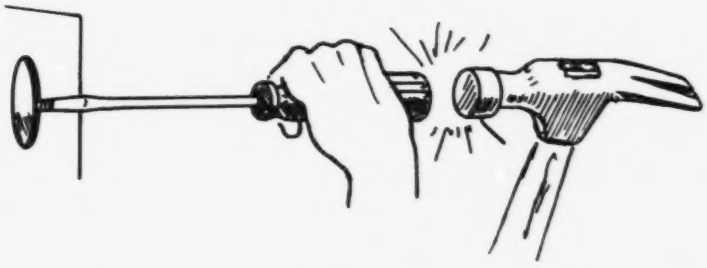
1. Locate 1/2" KO (knockout) to be removed
2. Place screwdriver on KO at point opposite unstamped piece (Figure 7)

FIGURE 7



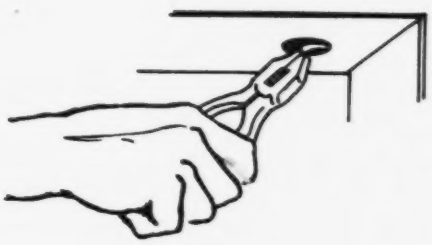
3. Hit screwdriver handle sharply with hammer (Figure 8)

FIGURE 8



4. Grasp raised KO with line technician's pliers
5. Bend KO back and forth until removed (Figure 9)

FIGURE 9



JOB SHEET #1

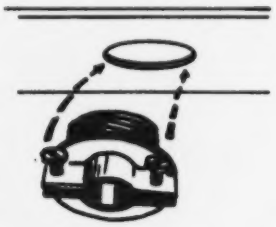
D. Install cable connector

1. Hold connector and unscrew locknut (Figure 10)

FIGURE 10

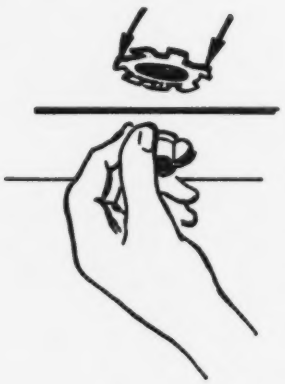
2. Place threads through KO opening (Figure 11)

FIGURE 11



3. Install locknut (Figure 12)

FIGURE 12

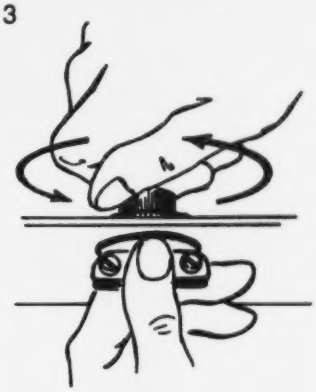


JOB SHEET #1

4. Tighten locknut (Figure 13)

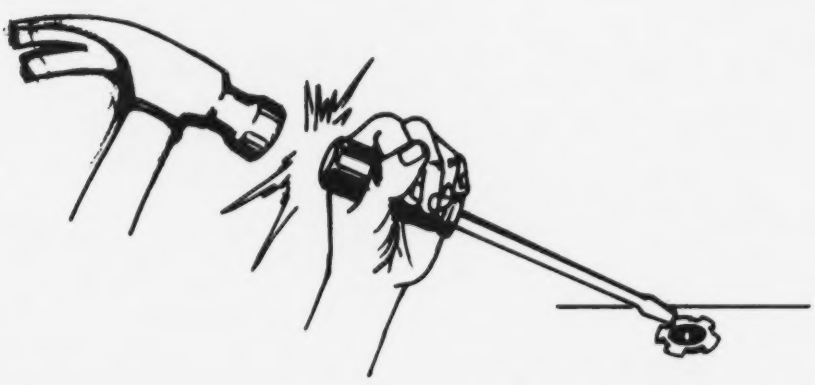
   (NOTE: Be sure serrated teeth are in contact with box.)

   FIGURE 13



5. Tighten locknut securely (Figure 14)

   FIGURE 14



E. Plug cord into power source

F. Bore holes for cable

   (NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below box depending on which route is the closest.)

CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.

JOB SHEET #1

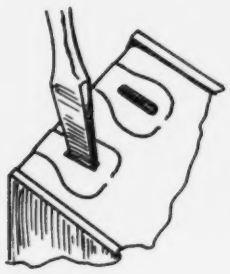
G. Run cable

1. Remove KOs from boxes

a. Place screwdriver in slot (Figure 15)

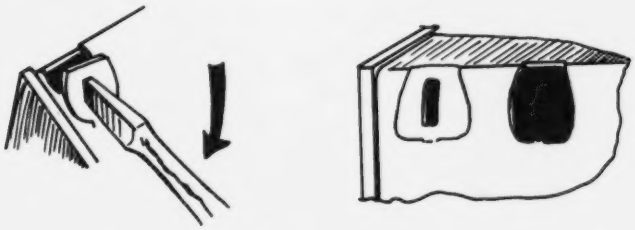
(NOTE: This is for metal boxes; most plastic boxes have KOs that are broken out by placing a screwdriver in the center and hitting with your hand or hammer.)

FIGURE 15



b. Pry KO out (Figure 16)

FIGURE 16



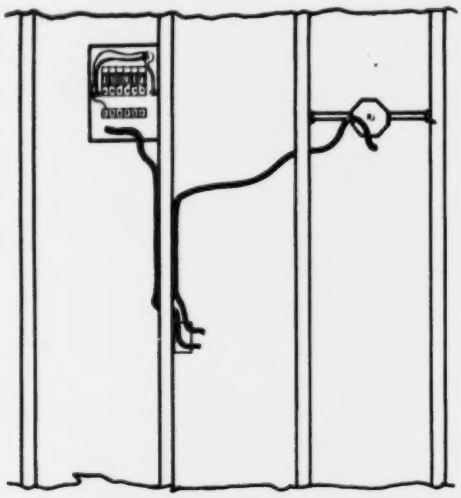
c. Wiggle screwdriver until KO pops loose (Figure 17)

FIGURE 17

JOB SHEET #1

2. Run cable between boxes (Figure 18)

FIGURE 18



(NOTE: Leave at least 8" extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus 1/2 of the width.)

H. Staple cable within 12" of all metal boxes, 8" of all nonmetallic boxes

(NOTE: Cables should be run flat when possible.)

I. Secure all cable clamps and connectors

CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

JOB SHEET #1

J. Strip cable insulation (Figure 19)

(NOTE: Cables could be stripped before they are installed in the boxes.)

FIGURE 19

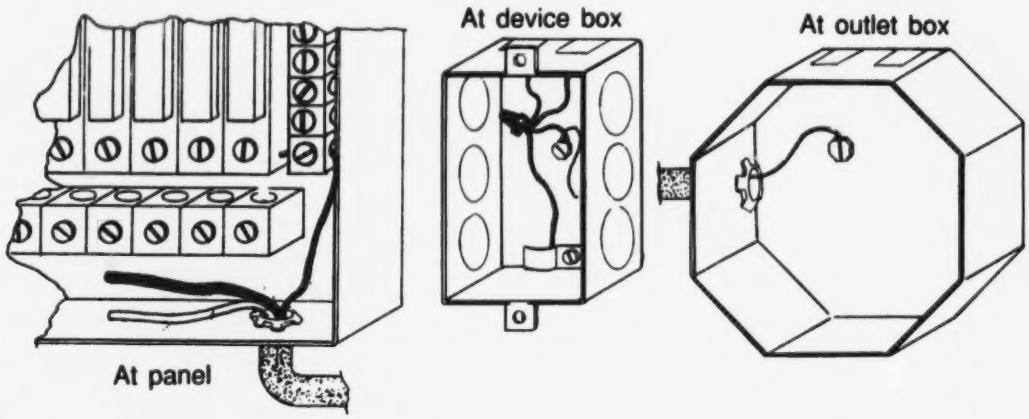
(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

CAUTION:
Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

JOB SHEET #1

K. Connect all grounding conductors (green or bare) (Figure 20)

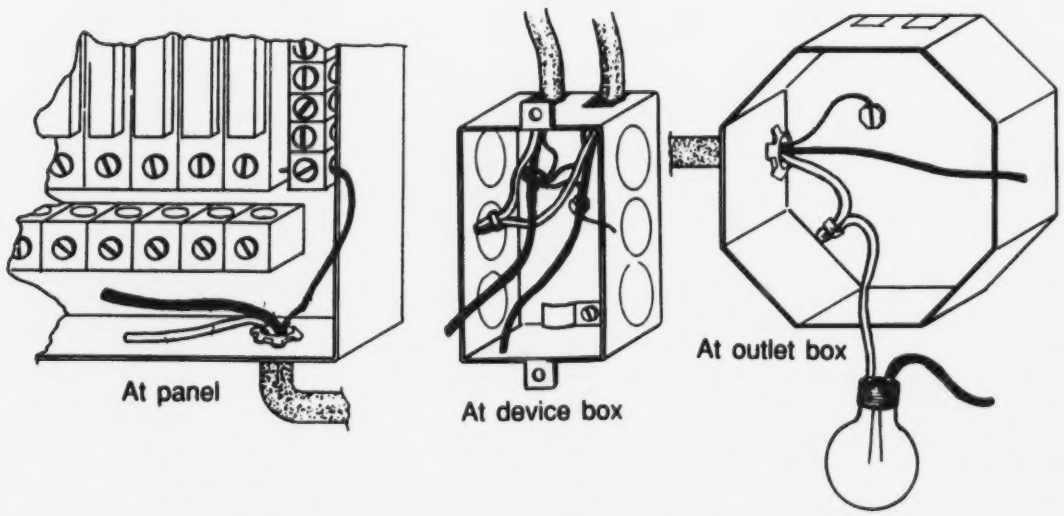
FIGURE 20



(NOTE: Always leave enough conductor to make removal and connection easy. Notice extra bend at panel.)

L. Connect all neutral conductors (white or natural gray) (Figure 21)

FIGURE 21

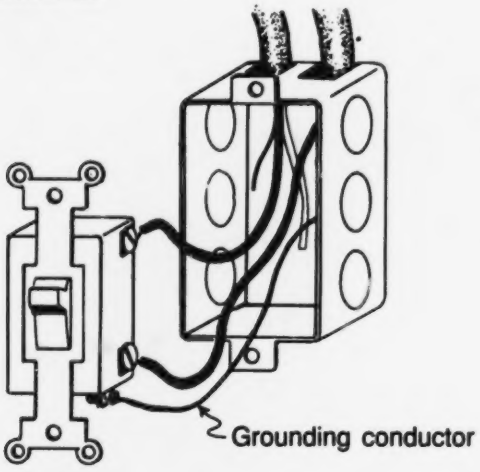


M. Connect return leg to remaining lampholder, conductor, or terminal

JOB SHEET #1

N. Connect switch (Figure 22)

FIGURE 22



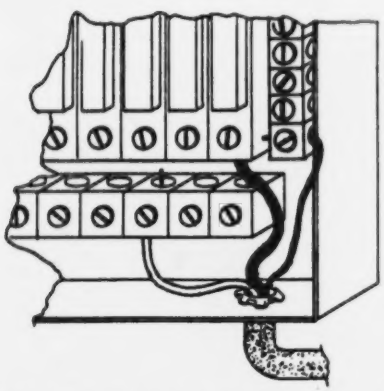
(NOTE: Be sure that the loop in the conductors is turned in the direction that the terminal tightens.)

O. Install the switch in box

(NOTE: Be sure and push all conductors into the box; don't rely on the installation of the switch to situate them.)

P. Connect ungrounded conductor to appropriate overcurrent device (Figure 23)

FIGURE 23



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious when working inside a panel.)

JOB SHEET #1

Q. Put single pole in OFF position

R. Turn breaker on

> **CAUTION:**
> Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

S. Turn on the switch

T. Have your instructor evaluate this project

U. Turn off breaker

V. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #2 — WIRE A SINGLE POLE SWITCH CONTROLLING A SINGLE LIGHTING OUTLET WITH THE SUPPLY LINE ENTERING THE LIGHTING OUTLET BOX

I. Tools and equipment

A. 12-2-G or 14-2-G NM cable

B. Device box

C. Octagon box

(NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors you will install.)

D. Staples

E. Single pole switch

F. Light socket

G. Bar hanger

(NOTE: If a bracket octagon box is used, or if this job is installed on a work board, a bar hanger will not be needed.)

H. Stud wall or work board

I. 120v supply

(NOTE: The overcurrent supply should not exceed your conductors NEC capacity rating.)

J. 3/8" cable clamp

K. 120v incandescent bulb

L. Wire connectors

(NOTE: Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors or solder would also be acceptable in the trade.)

M. Two 16 penny nails

N. 2 drywall nails

O. Electrician's hammer

P. Standard screwdriver

JOB SHEET #2

Q. Line technician's pliers

R. Long nose pliers

S. Pocket knife

T. Wire strippers

U. Tool pouch

V. Drill motor or bit brace

W. 1/2" or larger wood bit

(NOTE: Hole should be large enough to safely accommodate cable.)

X. Extension cord

Y. Safety glasses

II. Procedure

A. Put on safety glasses

B. Mount boxes

(NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)

C. Remove a half-inch knockout from the panel

D. Install cable connector

E. Plug cord into power source

F. Bore holes for cable

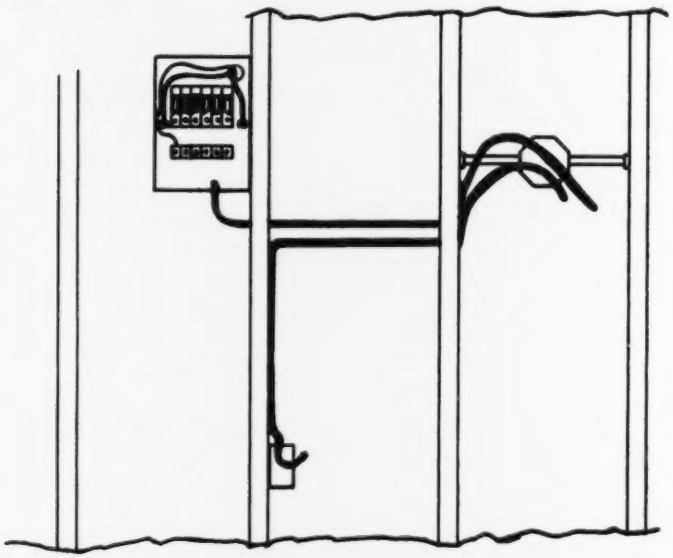
(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below box depending on which route is the closest.)

CAUTION:
Be sure and hold the drill securely. A loose grip can cause an accident.

JOB SHEET #2

G. Run cable (Figure 24)

FIGURE 24



(NOTE: Leave at least 8" extending past the surface of device and lighting outlet boxes, and enough to reach the top of panel plus half the width. The cable from the switch should enter the outlet box through the hole closest to the switch for later identification.)

H. Staple cable within 12" of all metal boxes, 8" of all nonmetallic boxes

I. Secure all cable clamps and connectors

CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

J. Strip cable insulation

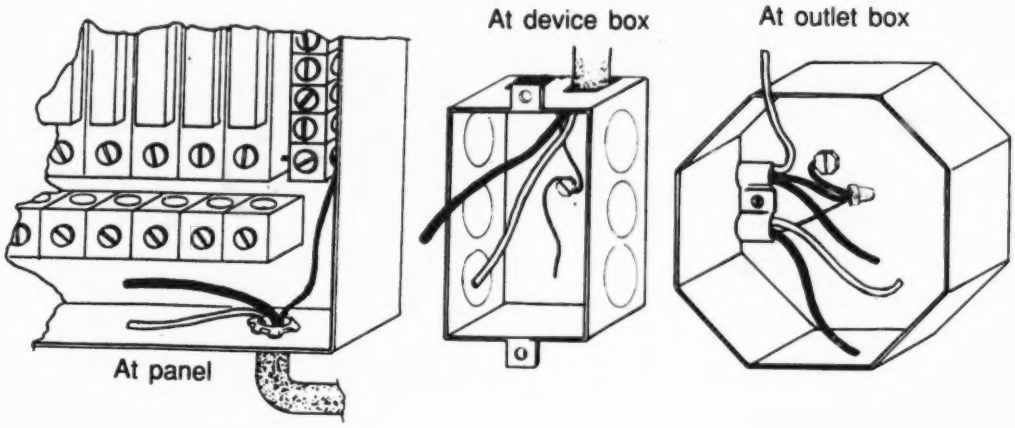
(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

CAUTION:
Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

JOB SHEET #2

K. Connect all grounding conductors (green or bare) (Figure 25)

FIGURE 25

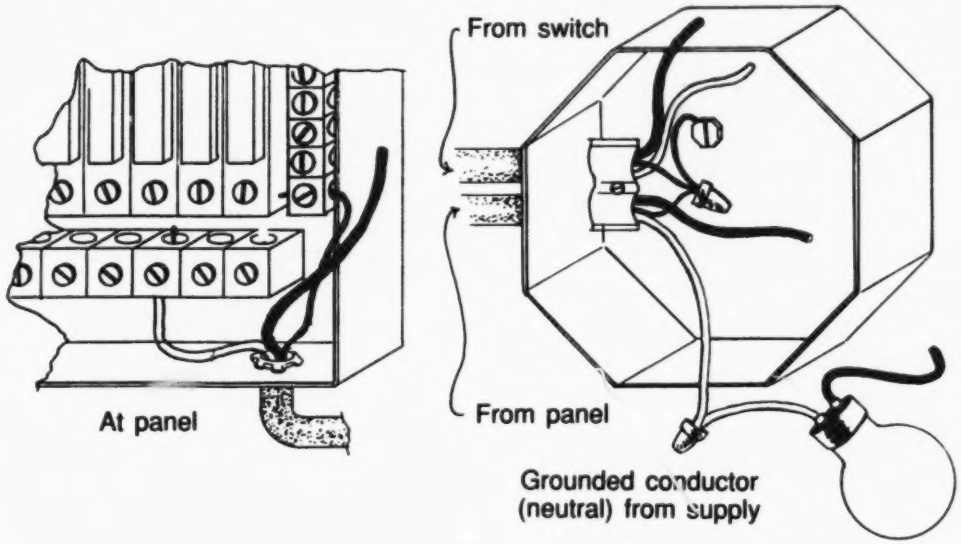


(NOTE: Always leave enough conductor to make removal and reconnection easy. Notice extra bend at panel.)

JOB SHEET #2

L. Connect all neutral conductors (white or natural gray) (Figure 26)

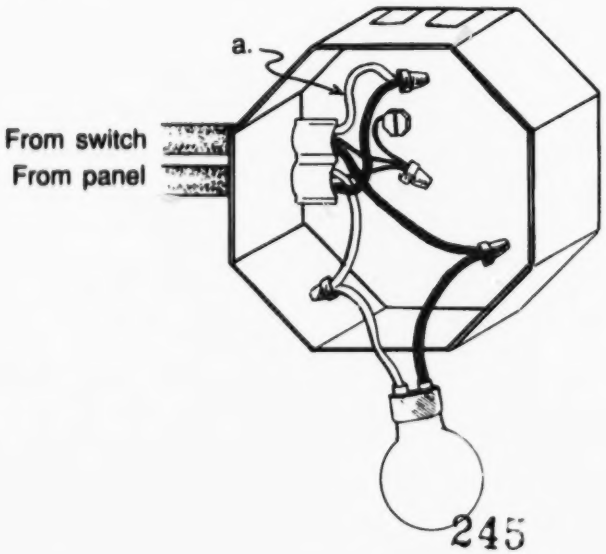
FIGURE 26



(NOTE: The grounded conductor in this circuit goes from the grounded terminal of the panel to the light and stops.)

M. Make up outlet box (Figure 27)

FIGURE 27



JOB SHEET #2

(NOTE: In switching situations you are allowed to use the white or gray conductor as the switch leg (a).)

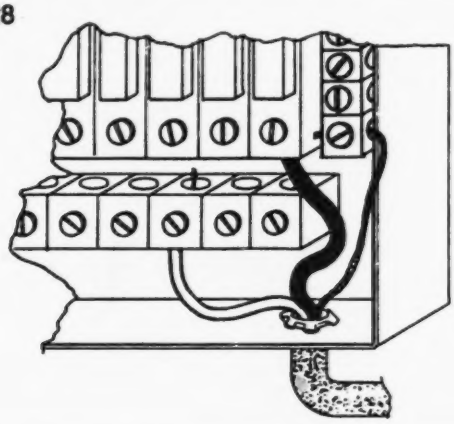
N. Install conductors on switch

(NOTE: It makes no difference which terminals the white and black conductors go on. The grounding however must go on the green, hex headed screw.)

O. Install switch in box

P. Connect ungrounded conductor to appropriate overcurrent protection (Figure 28)

FIGURE 28



CAUTION:
Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

Q. Put switch in OFF position

R. Turn breaker on

CAUTION:
Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

S. Turn on the switch

T. Have your instructor evaluate this project

U. Turn off breaker

V. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #3 — WIRE A THREE-WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING A SINGLE LIGHTING OUTLET

I. Tools and equipment

A. 12-2-G or 14-2-G and 12-3-G OR 14-3g NM cable

B. Two device boxes

C. Octagon box

(NOTE: Be sure your boxes have an NEC capacity rating to accommodate the conductors installed.)

D. Staples

E. Two 3-way switches

F. Light socket

G. Bar hanger

(NOTE: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)

H. Stud wall or work board

I. 120v supply

(NOTE: The overcurrent supply should not exceed the conductors NEC capacity rating.)

J. 3/8" cable clamp

K. 120v incandescent bulb

L. Wire connector

(NOTE: Twist-on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)

M. Two 16 penny nails

N. 2 drywall nails

O. Electrician's hammer

P. Standard screwdriver

JOB SHEET #3

Q. Line technician's pliers

R. Needle nose pliers

S. Pocket knife

T. Wire strippers

U. Tool pouch

V. Drill motor or bit brace

W. 1/2" or larger wood bit

(NOTE: Holes should be large enough to safely accommodate the cables.)

X. Extension cord

Y. Safety glasses

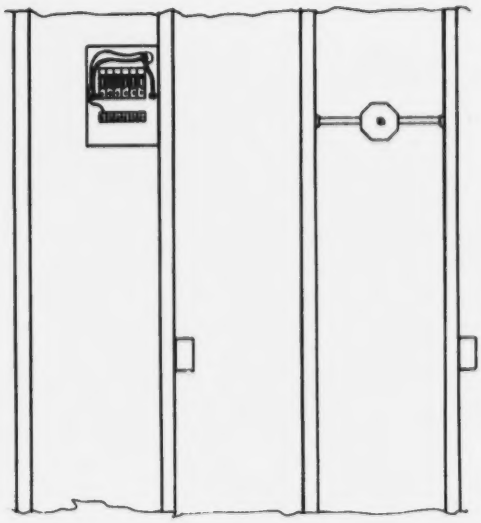
II. Procedure

A. Put on safety glasses

B. Mount boxes (Figure 29)

(NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)

FIGURE 29



JOB SHEET #3

C. Remove a half-inch knockout from the panel

D. Install cable connector

E. Plug cord into power source

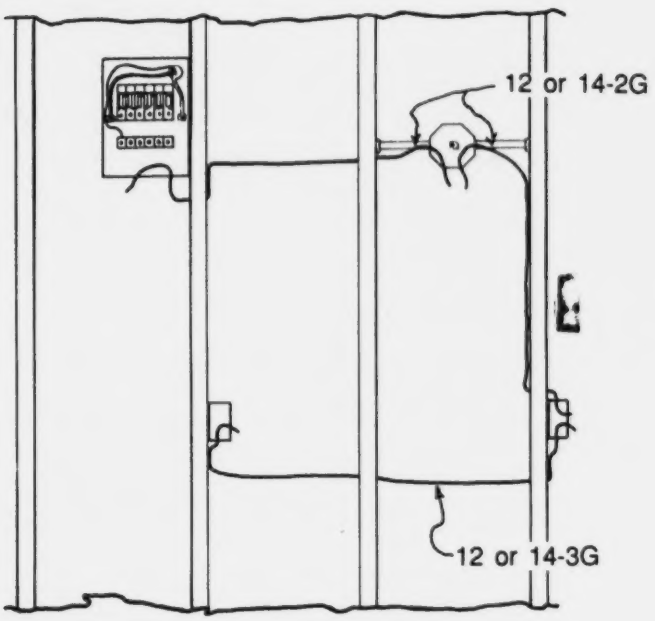
F. Bore holes for cable

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below depending on which route is the closest.)

CAUTION:
Be sure to hold the drill securely. A loose grip can cause an accident.

G. Run cable (Figure 30)

FIGURE 30



(NOTE: Leave at least 8" extending past the surface of device and lighting outlet boxes, and enough to reach the top of panel plus half the width.)

JOB SHEET #3

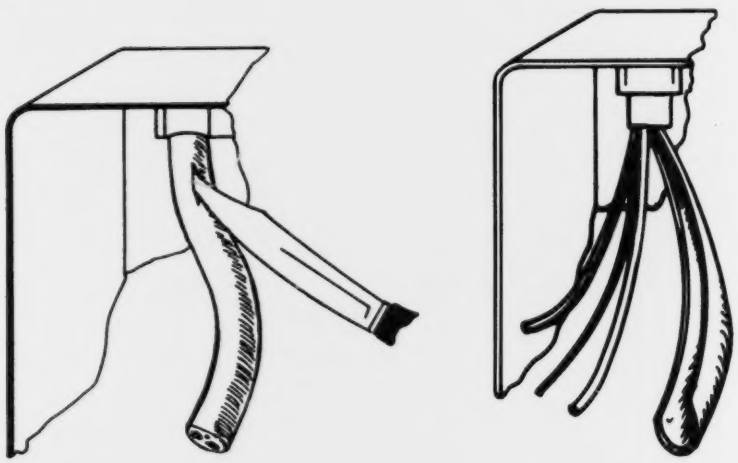
H. Staple cable within 12" of all metal boxes, 8" of all nonmetallic boxes

I. Secure all cable clamps and connectors

CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

J. Strip cable insulation (Figure 31)

FIGURE 31



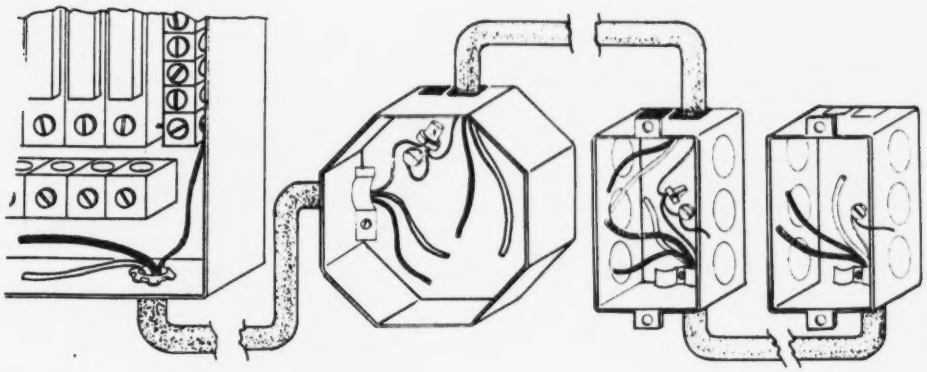
(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

CAUTION:
Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

JOB SHEET #3

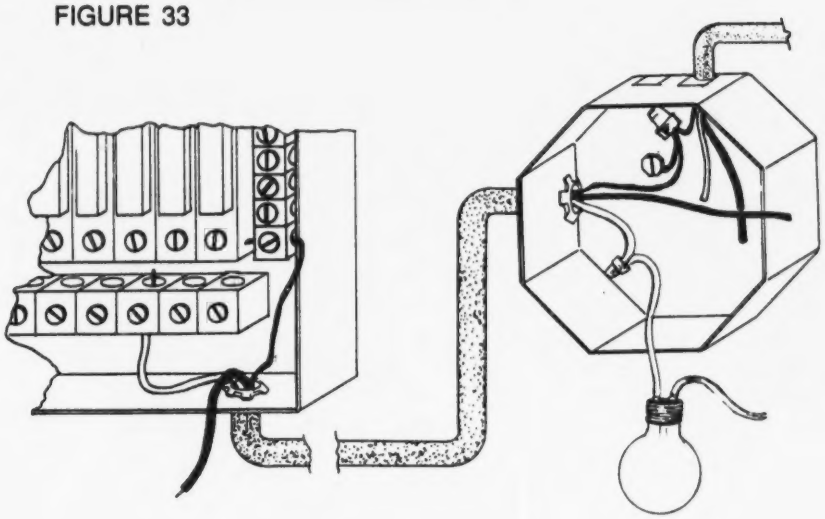
K. Connect all grounding conductors (Figure 32)

FIGURE 32



L. Connect neutral conductors (Figure 33)

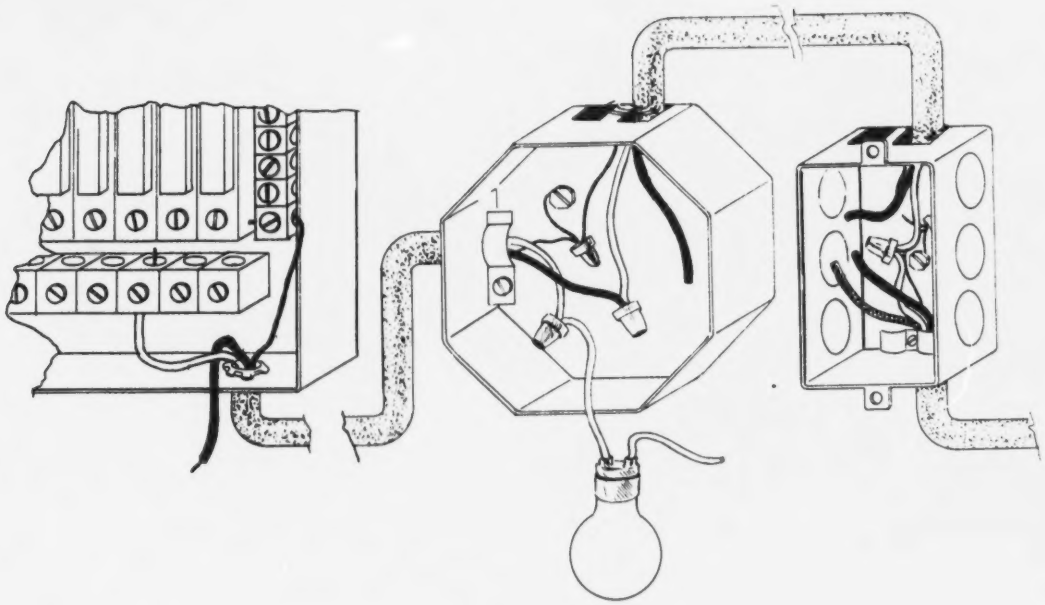
FIGURE 33



JOB SHEET #3

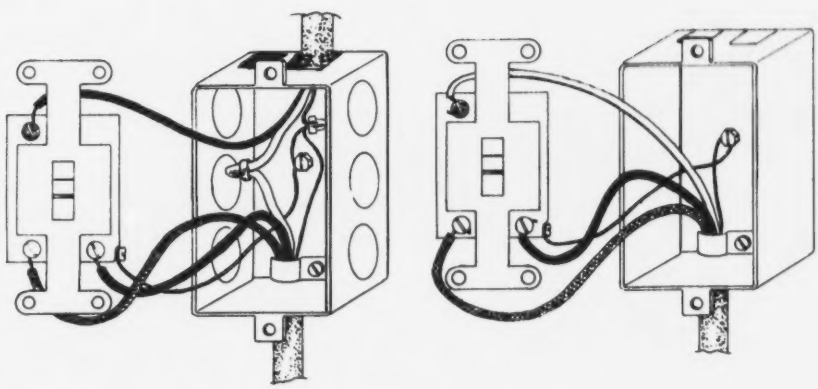
M. Connect switch legs (Figure 34)

FIGURE 34



N. Install switches (Figure 35)

FIGURE 35



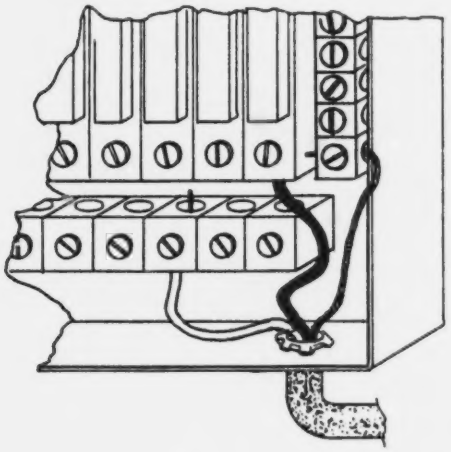
JOB SHEET #3

(NOTE: In all three-way circuits the switch leg goes on one common screw and the return leg goes on the other with travelers connecting to the remaining screws on each device. The grounding screw attaches to the green, hex headed screw on the strap.)

O. Connect return leg to socket

P. Connect ungrounded conductor to appropriate overcurrent device (Figure 36)

FIGURE 36



CAUTION:
Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

Q. Turn breaker on

CAUTION:
Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

R. Change the position of the switches in alternating movements

(NOTE: Be sure the light can be turned on or off from either switch as well as on at one and off at the other.)

S. Have instructor evaluate this project

T. Turn off breaker

U. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #4 — INSTALL A DUPLEX GROUNDING TYPE RECEPTACLE

I. Tools and equipment

A. Line technician's pliers

B. Long nose pliers

C. Standard knife

D. Pocket knife

E. Wire strippers

F. Electrician's hammer

G. 12-2 or 114-2 G NM cable

H. Device box

I. Electrical supply

J. Staples

K. 3/8" cable connector

L. Stud wall or work board

M. Tool pouch

N. Folding rule with sliding scale or steel tape

O. Safety glasses

P. Drill motor or bit brace

Q. 1/2" or larger wood bit

(NOTE: Holes should be large enough to accommodate cables safely.)

R. Extension cord

S. Duplex grounding type receptacle

T. Neon test light or voltmeter

JOB SHEET #4

II. Procedure

A. Put on safety glasses

B. Mount box

(NOTE: Remember that box set-out depends on the thickness of the wall covering to be installed.)

C. Remove a half-inch knockout from the panel

(NOTE: Line technician's pliers may be needed to finish removing the raised knockout.)

D. Install cable connector

E. Bore holes for cable

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

CAUTION:
Be sure and hold the drill securely. A loose grip can cause an accident.

F. Run cable

(NOTE: Leave at least 8" extending past the surface of device box, and enough to reach the top panel plus half the width.)

G. Staple cable within 12" of metal boxes, 8" of nonmetallic boxes

H. Secure all cable clamps and connectors

CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

JOB SHEET #4

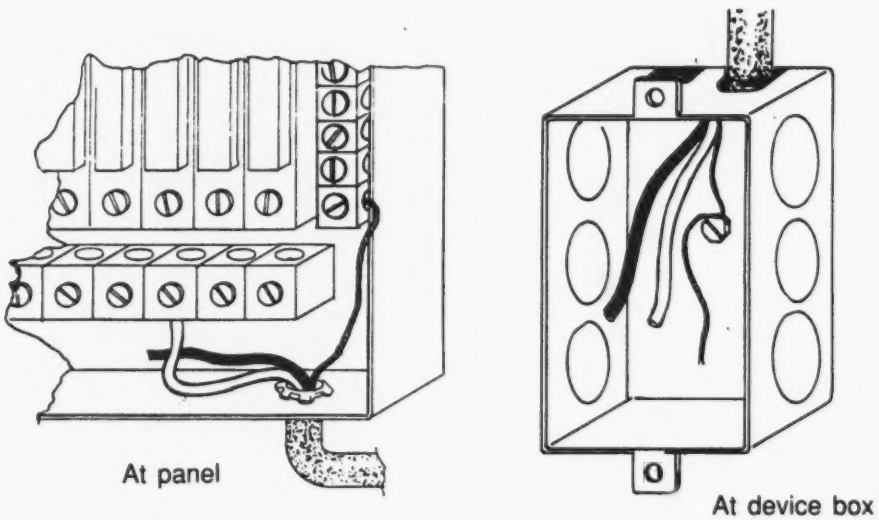
I. Strip cable insulation at device box and panel

(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

> **CAUTION:**
> Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

J. Connect equipment grounding conductors and circuit neutral (Figure 37)

FIGURE 37

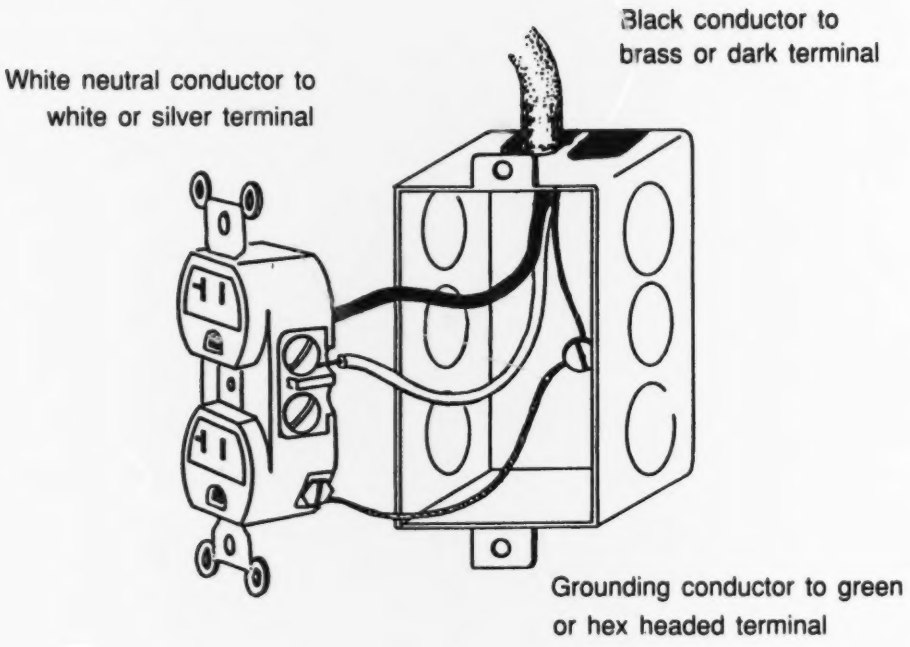


(NOTE: In a residence, all circuit neutrals and equipment grounding conductors would be connected at one time; the procedure is called panel make-up.)

JOB SHEET #4

K. Install receptacle (Figure 38)

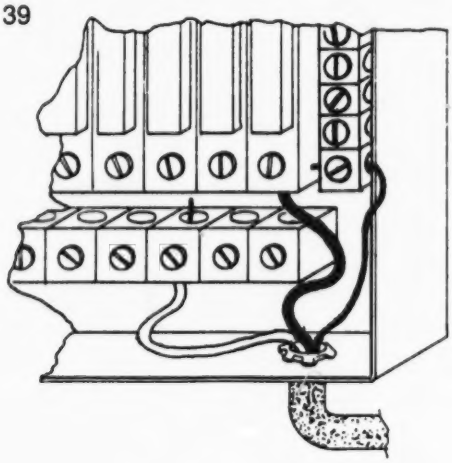
FIGURE 38



JOB SHEET #4

L. Connect ungrounded conductor to appropriate overcurrent device (Figure 39)

FIGURE 39



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

M. Turn breaker on or screw fuse in

> **CAUTION:**
> Stand to the side of the panel when turning on the breaker. A short circuit could cause molten metal to fly from the panel.

N. Test receptacle with neon test light or voltmeter

O. Have instructor evaluate this project

P. Turn off breaker

Q. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #5 — INSTALL A MULTI-CIRCUIT, SPLIT-WIRED DUPLEX GROUNDING TYPE RECEPTACLE

I. Tools and equipment

- A. Line technician's pliers
- B. Long nose pliers
- C. Standard screwdriver
- D. Pocket knife
- E. Wire strippers
- F. Electrician's hammer
- G. 12-3 or 14-2G NM cable
- H. Device box
- I. Electrical supply
- J. Staples
- K. 3/8" cable connector
- L. Stud wall or work board
- M. Tool pouch
- N. Folding rule with sliding scale or steel tape
- O. Safety glasses
- P. Drill motor or bit brace
- Q. 1/2" or larger wood bit
- R. Extension cord

II. Procedure

- A. Put on safety glasses

JOB SHEET #5

B. Mount box

(NOTE: Remember that the box set-out depends upon the thickness of the wall covering to be installed.)

C. Remove a half-inch knockout from the panel

(NOTE: Line technician's pliers may be needed to finish removing the raised knockout.)

D. Install cable connector

E. Bore holes for cable

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

CAUTION:
Be sure and hold the drill securely. A loose grip can cause an accident.

F. Run cable

(NOTE: Leave at least 8" extending past the surface of device box, and enough to reach the top of panel plus half the width.)

G. Staple cable within 12" of the box

H. Secure all cable clamps and connectors

CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

I. Strip cable insulation at device box and panel

CAUTION:
Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

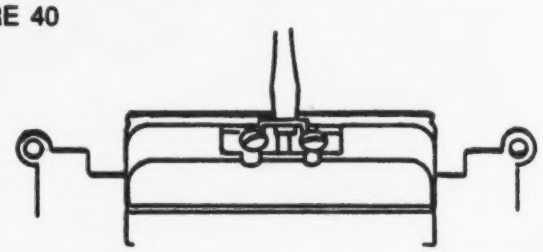
J. Connect equipment grounding conductors and panel neutral

(NOTE: In a residence, all circuit neutrals and equipment grounding conductors would be connected at one time; the procedure is called panel make-up.)

JOB SHEET #5

K. Break connecting fin from ungrounded side of receptacle (Figure 40)

FIGURE 40



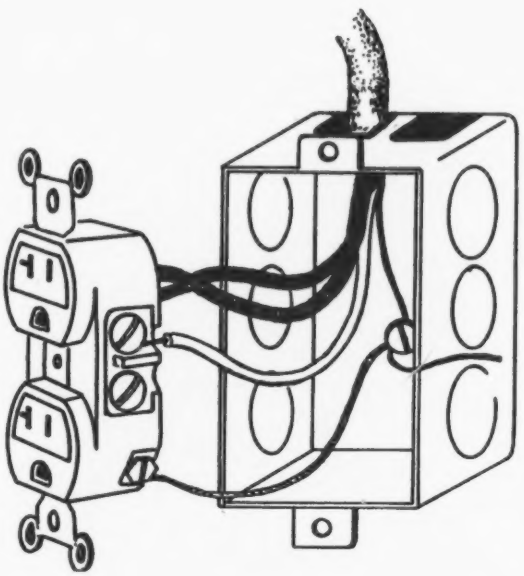
(NOTE: Repeated bending motions will probably be needed to remove the connecting fin.)

L. Install receptacle (Figure 41)

FIGURE 41

Black wire and red wire to split terminals

Neutral to white terminal

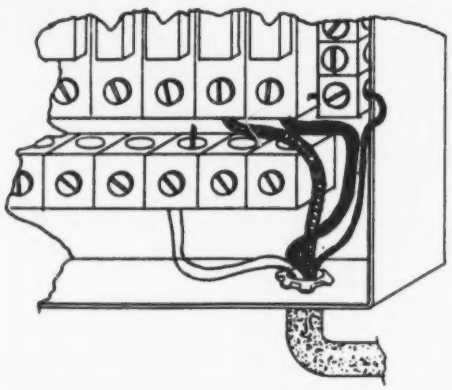


(NOTE: A common neutral is allowed on multi-wire branch circuits where there is a dual voltage potential difference between ungrounded conductors.)

JOB SHEET #5

M. Connect ungrounded conductor to appropriate overcurrent devices (Figure 42)

FIGURE 42



(NOTE: Be sure the breakers are off or the fuses are out before connecting these conductors. Always be safety conscious.)

N. Turn breaker on or screw fuse in

CAUTION:
Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

O. Test receptacles with neon test light or voltmeter

P. Have instructor evaluate this project

Q. Turn off breaker

R. Clean work area

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #6 — WIRE A SWITCH CONTROLLED, SPLIT-WIRED RECEPTACLE

I. Tools and equipment

A. 12-2G or 14-2-G NM cable

B. 12-3-G or 14-3-G NM cable

C. Two device boxes

(NOTE: Be sure boxes have an NEC capacity rating to accommodate the conductors you will install.)

D. Staples

E. Single pole switch

F. Duplex grounding type receptacle

G. Stud wall or work board

H. 120v supply

(NOTE: The overcurrent protection on this supply should not exceed the conductors NEC capacity rating.)

I. 3/8" cable clamp

J. Wire connectors

K. Four 16 penny nails or other fasteners as needed to secure the boxes

L. Electrician's hammer

M. Standard screwdriver

N. Line technician's pliers

O. Needle-nose pliers

P. Pocket knife

Q. Wire strippers

R. Tool pouch

S. Drill motor or bit brace

T. 1/2" or larger wood bit

JOB SHEET #6

U. Extension cord

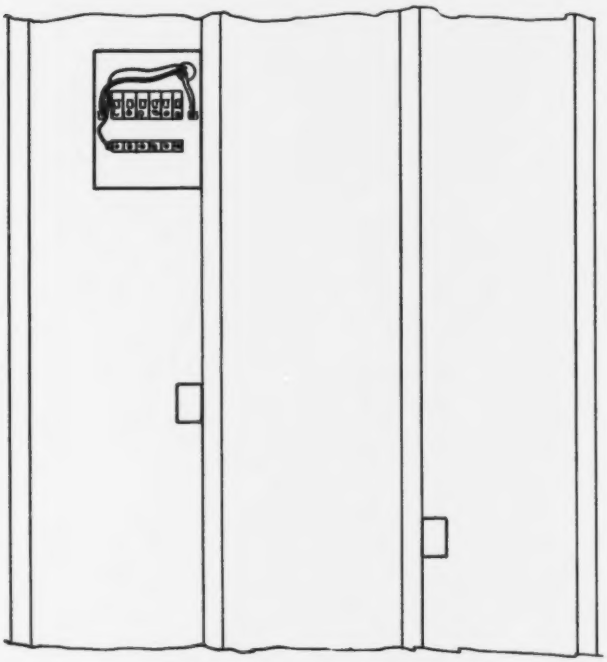
V. Safety glasses

II. Procedure

A. Put on safety glasses

B. Mount boxes (Figure 43)

FIGURE 43



C. Remove a half-inch knockout from the panel

D. Install cable connector

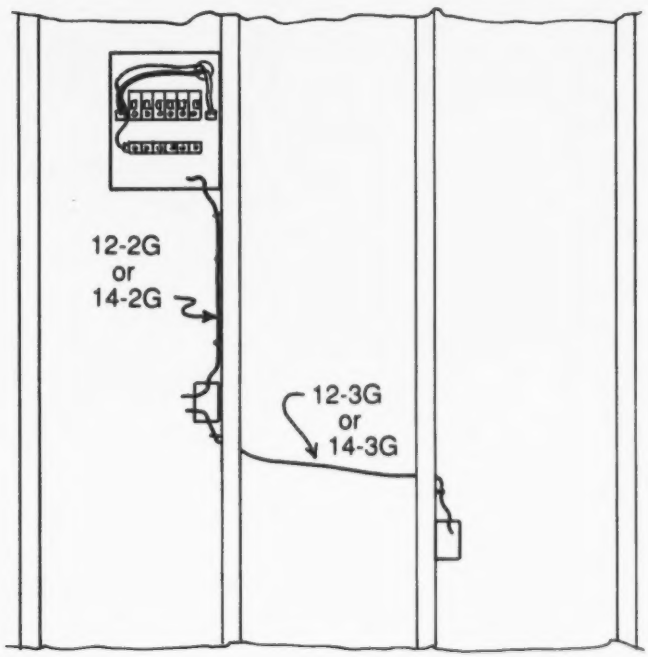
JOB SHEET #6

E. Bore holes for cable

(NOTE: Holes should be drilled as close to the center [front to back] of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

F. Run cable between boxes and to panel (Figure 44)

FIGURE 44



(NOTE: Leave at least 8" extending past the surface of your device boxes, and enough to reach the top of your panel plus half the width.)

G. Staple cable within 12" of metal boxes, 8" of all nonmetallic boxes

H. Secure all cable clamps and connectors

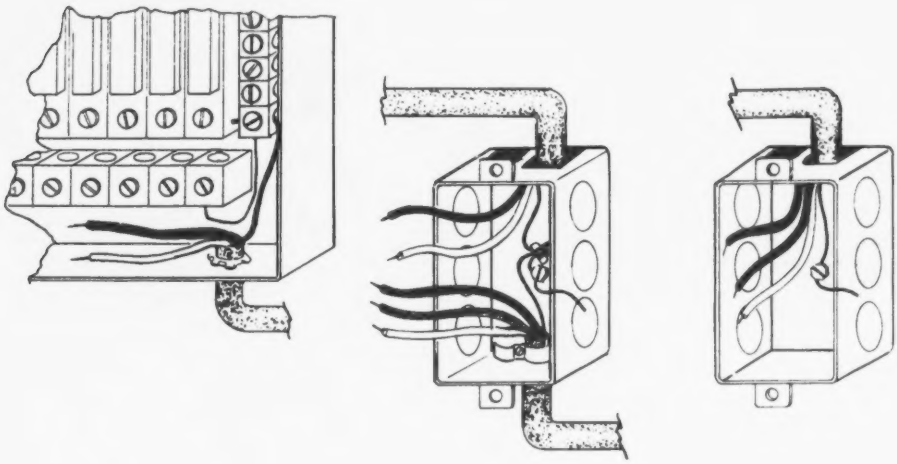
CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

JOB SHEET #6

I. Strip cable insulation at device box and panel

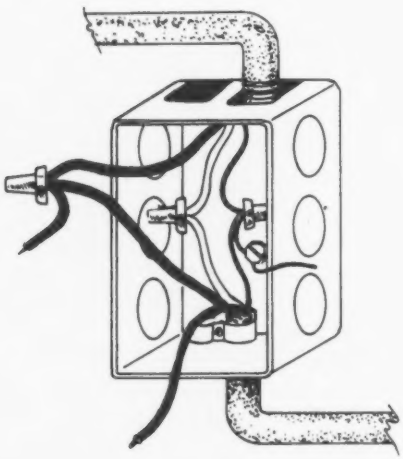
J. Connect equipment grounding conductors (Figure 45)

FIGURE 45



K. Make up switch box (Figure 46)

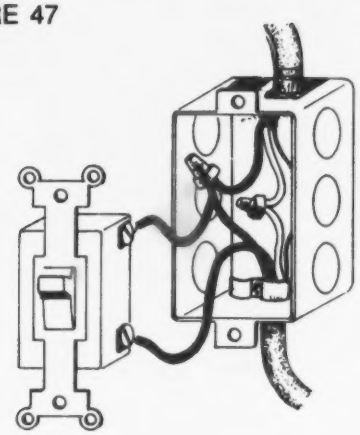
FIGURE 46



JOB SHEET #6

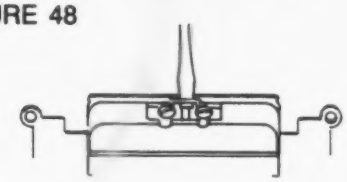
L. Install switch (Figure 47)

FIGURE 47



M. Break connecting fin from ungrounded side of receptacle (Figure 48)

FIGURE 48

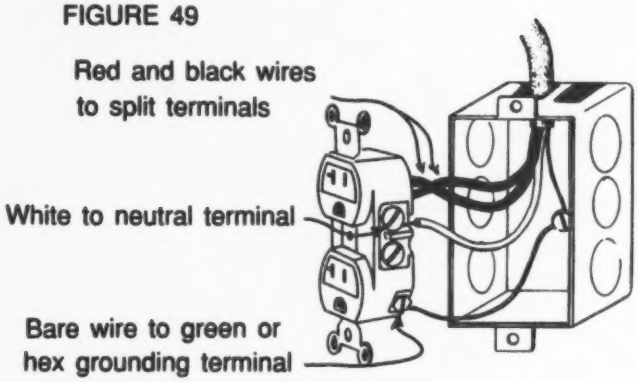


(NOTE: Repeated bending motions will probably be needed to remove the connecting fin.)

JOB SHEET #6

N. Install receptacle (Figure 49)

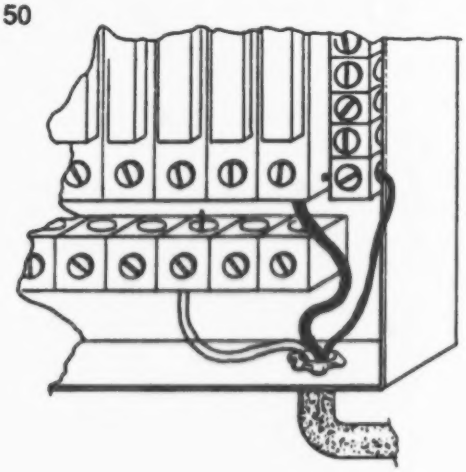
FIGURE 49



(NOTE: If the circuit continues, neutrals must be pigtailed before they are installed to the device terminal.)

O. Connect grounded and ungrounded conductors (Figure 50)

FIGURE 50



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

P. Turn breaker on or screw fuse in

CAUTION:
Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

JOB SHEET #6

Q. Test receptacle with neon test light or voltmeter

R. Have your instructor evaluate this project

S. Turn off breaker

T. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #7 — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A SINGLE POLE SWITCH

I. Tools and equipment

A. 12-2-G or 14-2-G NM cable

B. 12-3-G or 14-3-G NM cable

C. Two device boxes

D. Octagon box and bar hanger

E. Light socket

F. 120 volt bulb

G. Staples

H. Single pole switch

I. Duplex grounding type receptacle

J. Stud wall or work board

K. 120v supply

(NOTE: The overcurrent protection on this supply should not exceed the conductors NEC capacity rating.)

L. Wire connectors

M. Four 16 penny nails or other fasteners as needed to secure the boxes

N. Electrician's hammer

O. Standard screwdriver

P. Line technician's pliers

Q. Long nose pliers

R. Pocket knife

S. Wire strippers

T. Tool pouch

U. Drill motor or bit brace

JOB SHEET #7

V. 1/2" or larger wood bit

W. Extension cord

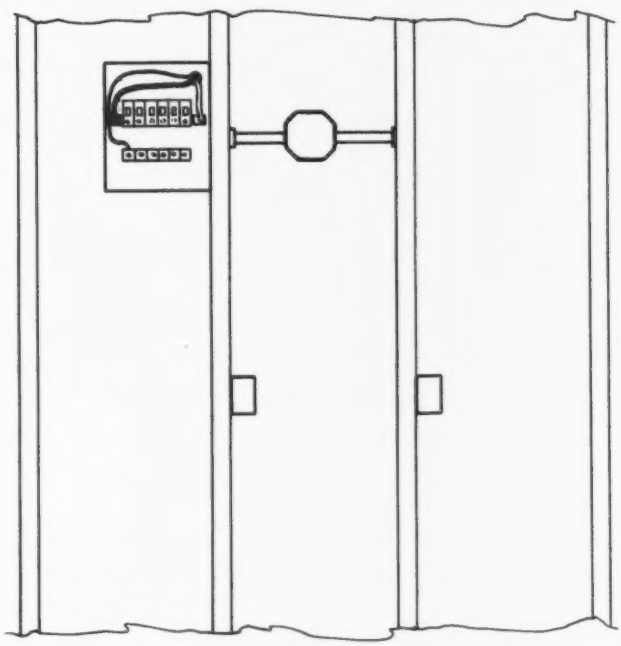
X. Safety glasses

II. Procedure

A. Put on safety glasses

B. Mount boxes (Figure 51)

FIGURE 51



C. Remove a half-inch knockout from the panel

D. Install cable connector

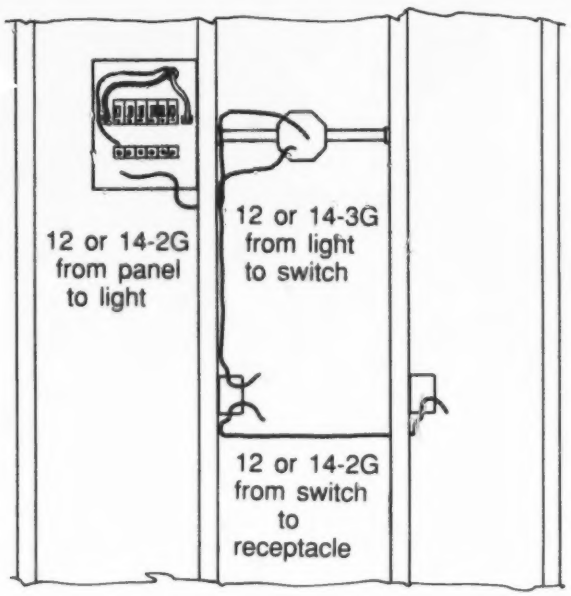
JOB SHEET #7

E. Bore holes for cable

(NOTE: Holes should be drilled as close to the center [front to back] as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

F. Run cable between boxes and to panel (Figure 52)

FIGURE 52



(NOTE: Leave at least 8" extending past the surface of device boxes, and enough to reach the top of panel plus half the width.)

G. Staple cable within 12" of metal boxes, 8" of nonmetallic boxes

H. Secure all cable clamps and connectors

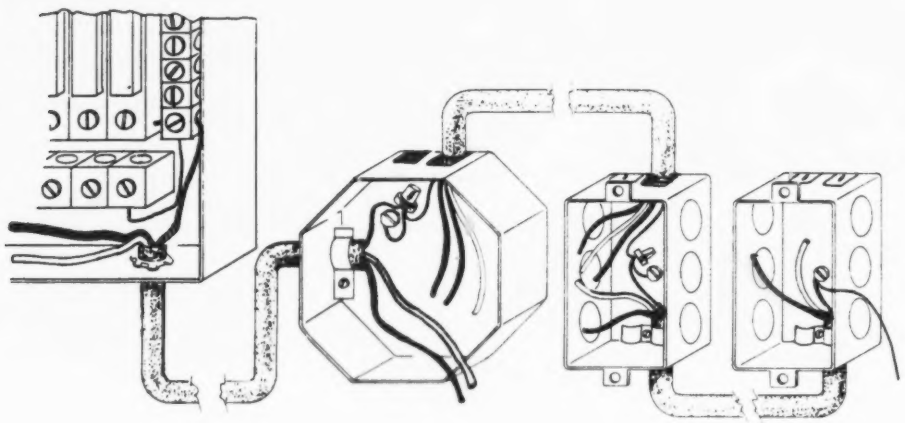
CAUTION:
Tighten clamps until the cable will not slip in the box; overtightening can cause an electrical short.

I. Strip cable insulation at device box and panel

JOB SHEET #7

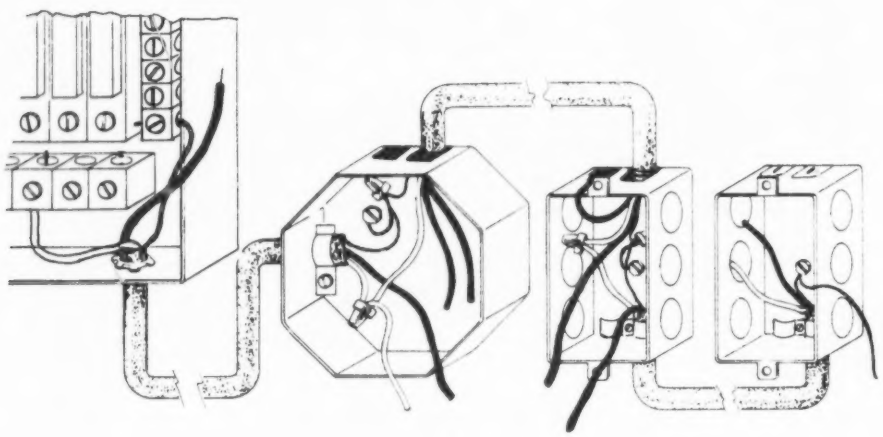
J. Connect equipment grounding conductors (Figure 53)

FIGURE 53



K. Make up neutral through the system (Figure 54)

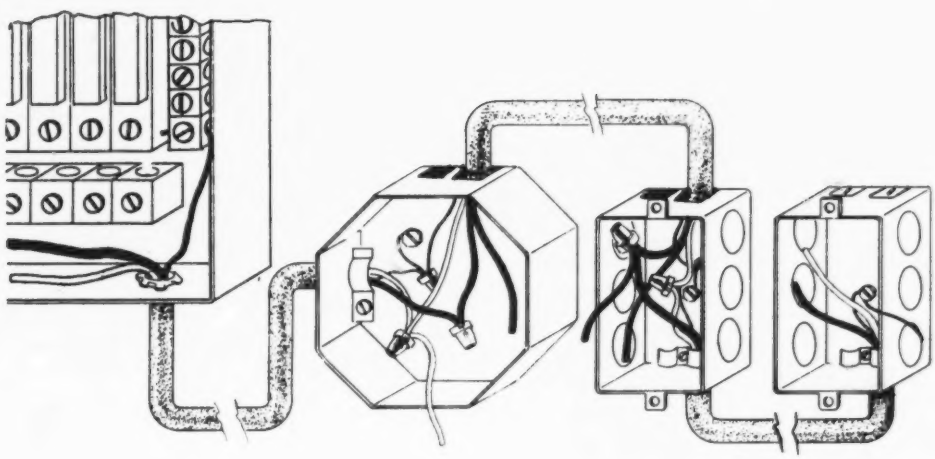
FIGURE 54



JOB SHEET #7

L. Make up switch, return, and feed through conductors (Figure 55)

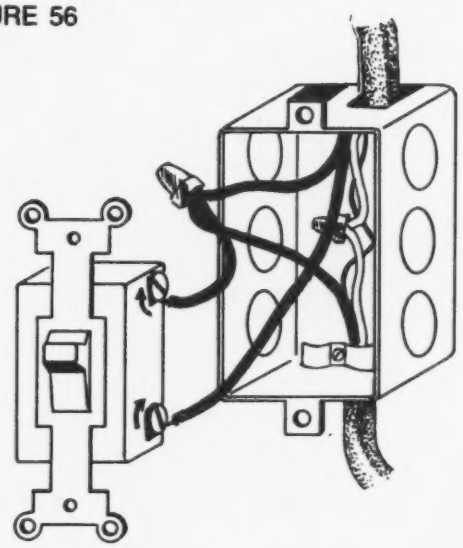
FIGURE 55



JOB SHEET #7

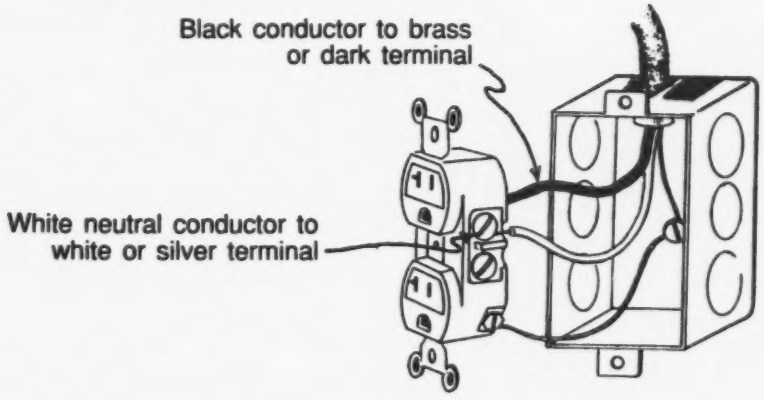
M. Install switch (Figure 56)

FIGURE 56



N. Install receptacle (Figure 57)

FIGURE 57

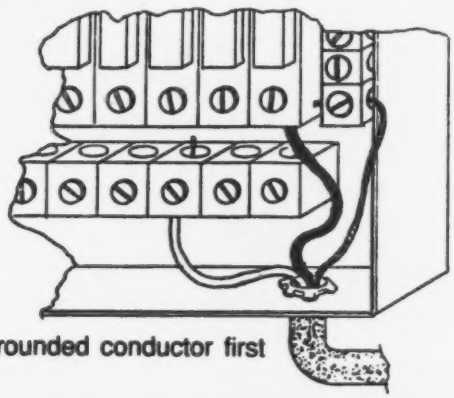


O. Connect return leg and neutral to light socket

JOB SHEET #7

P. Connect ungrounded conductor (Figure 58)

FIGURE 58



Connect grounded conductor first

(NOTE: Be sure the breaker is off or the fuse is out before connecting these conductors. Always be safety conscious.)

Q. Turn on breaker or screw in fuse

R. Turn on switch

(NOTE: Light should burn.)

S. Test receptacle with neon test light or voltmeter

T. Have your instructor inspect this project

U. Turn off breakers

V. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #8 — INSTALL AN OVERHEAD RACEWAY WITH SERVICE ENTRANCE CONDUCTORS TO A METER BASE

I. Tools and equipment

A. Flat blade screwdriver

B. Line technician's pliers

C. Hammer

D. Knife

E. Hacksaw

F. Folding rule with sliding scale

G. Meter base

H. Service entrance cap (1-1/2" clamp-on type)

I. 3' of 1-1/2" rigid metal conduit (threaded on one end)

J. 12' of #2 copper TW (two 6" pieces)

K. 6' of #4 copper

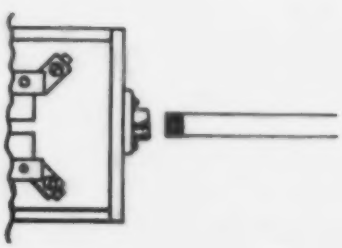
L. Safety glasses

II. Procedure

A. Put on safety glasses

B. Screw threaded end of raceway into hub (Figure 59)

FIGURE 59



JOB SHEET #8

C. Remove cover and separator from weatherhead (Figure 60)

FIGURE 60

D. Clamp weatherhead base onto the end of the service raceway (Figure 61)

FIGURE 61

E. Install conductors in the raceway

(NOTE: Start at weatherhead end.)

F. Connect grounded conductor to grounding lug

(NOTE: When possible leave grounded conductor long enough to connect to disconnect equipment grounding bar.)

G. Remove 1" to 1-1/2" of insulation from ungrounded conductors and connect to line lugs

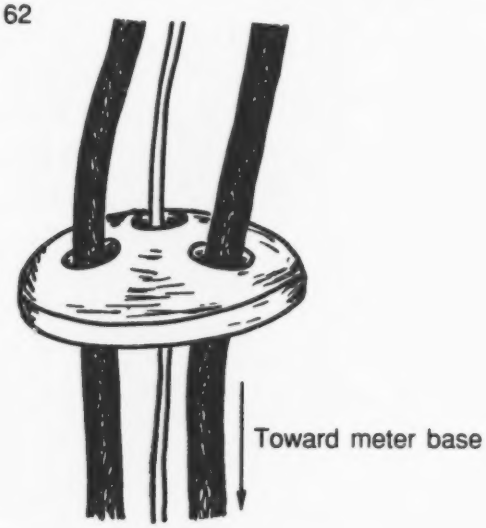
H. Knock out three outlined holes in the entrance cap separator

I. Put grounded conductor through center hole

JOB SHEET #8

J. Put ungrounded conductors through side holes (Figure 62)

FIGURE 62



K. Gently start forming conductors so the separator will fit back in the base

(NOTE: Care must be taken while you are bending the curvature in the conductors to prevent damage to the plastic conductor separator.)

L. Replace service entrance cap cover

M. Clean work area and store tools properly

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #9 — CONNECT METER BASE ASSEMBLY TO LOAD CENTER OR PANEL

I. Tools and equipment

A. Standard screwdriver

B. Line technician's pliers

C. Hammer

D. Knife

E. Level

F. Folding rule or steel tape

G. Awl

H. Meter base assembly from Job Sheet #8

I. Two 1-1/4" insulating bushings

J. Four 1-1/4" locknuts

K. One 1-1/4" reamed nipple long enough to connect meter base to distribution panel

(NOTE: Nipple, bushings and locknuts can be larger than 1-1/4" if conductor size or necessity mandates.)

L. #4 copper (1 piece)

M. #2 TW copper (2 pieces)

N. Eight 1" #12 metal tapping screws

O. One 100 amp 1 phase 3 wire SN. load center

P. One 1-1/2" rigid conduit strap

Q. 2" x 4" mock up wall or roughed in residential dwelling

R. Safety glasses

JOB SHEET #9

II. Procedure

A. Put on safety glasses

B. Mount load center between studs with metal tapping screws

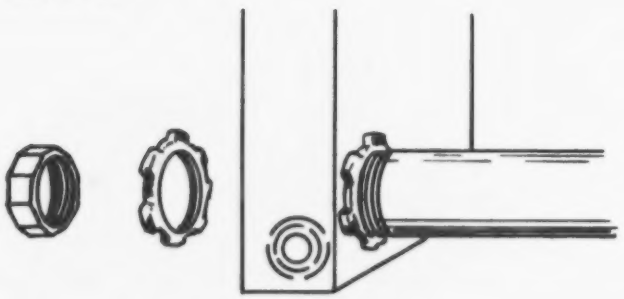
(NOTE: Panel height should be adjusted so that knockouts will line up with meter base between 5' and 6'. The utility company will give you their recommended height.)

C. Remove load center knockout that will align with meter base at correct height

D. Install nipple in opening with a locknut on the backside of load center and a locknut and bushing on the inside (Figure 63)

(NOTE: Be sure that locknuts are installed tightly with teeth into the metal. Also be sure to check local codes on bonding.)

FIGURE 63



E. Remove appropriate knockout from meter base

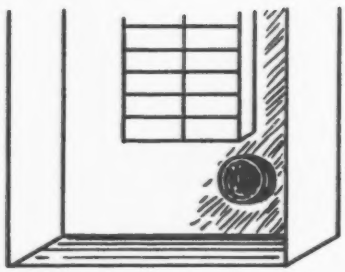
F. Put back up locknut for meter base on nipple

G. Place nipple through meter base knockout and secure loosely with one screw (Figure 64)

(NOTE: Cut off excess nipple, leave only what is needed for locknut and bushing.)

JOB SHEET #9

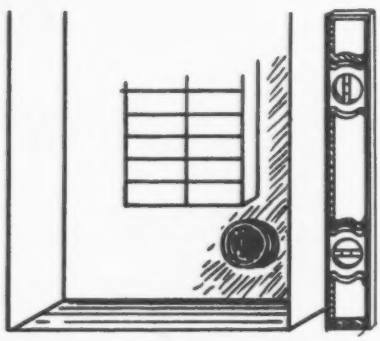
FIGURE 64



H. Install internal locknut and bushing

I. Place level on side of meter base and secure box with mounting screws when leveled (Figure 65)

FIGURE 65



J. Put level on service raceway and secure raceway with strap when leveled

K. Install grounded conductor in nipple and connect to meter base and load center grounded lugs

(NOTE: Make all bends in conductors as square as possible while maintaining a radius equal to at least five time the diameter. Make sure to stay as far as possible from load and line lugs in routing of the grounded conductors.)

L. Install ungrounded conductors in nipple

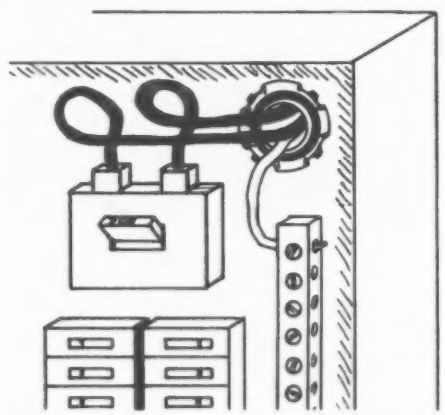
M. Strip about 1-1/2" insulation from each of the ungrounded conductors, form them and connect them to meter load lugs

N. Form ungrounded conductors in load center

JOB SHEET #9

O. Cut off excess and connect to load center line lugs (Figure 66)

FIGURE 66



(NOTE: The service system is still without a grounding electrode conductor. This conductor can originate at the load center, or in the meter base. It can terminate at a cold water pipe or made electrode.)

ELECTRICAL BASIC SKILLS
UNIT IV

JOB SHEET #10 — INSTALL PLATES ON DEVICES

I. Tools and equipment

A. Standard screwdrivers

B. Plates

C. Safety glasses

D. Device installation ready for trim out

E. Awl

F. Tap tool

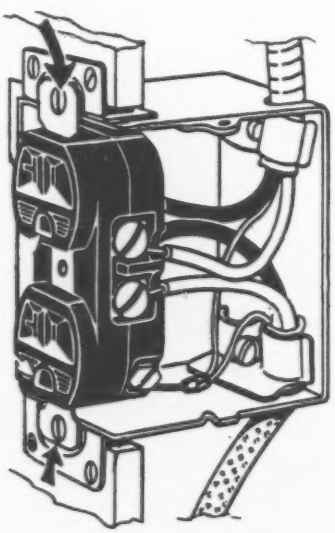
II. Procedure

A. Put on safety glasses

B. Square up the device or devices (Figure 67)

(NOTE: The slots for the device securing screws are elongated to allow straightening of the device even if the box is not straight.)

FIGURE 67



JOB SHEET #10

1. Single device
   a. Loosen device mounting screws
   b. Hold plate over device
   c. Turn until straight

   (NOTE: The device should turn with the plate if it is flush installed.)

2. Multiple devices
   a. Loosen device mounting screws
   b. Hold plate over devices
   c. Level up plate
   d. Line up plate securing screws with awl

   (NOTE: If there are several multiple device plates to install, a straightening jig can be made to level up the plates and secure the devices in one step. See Figure 68.)

FIGURE 68

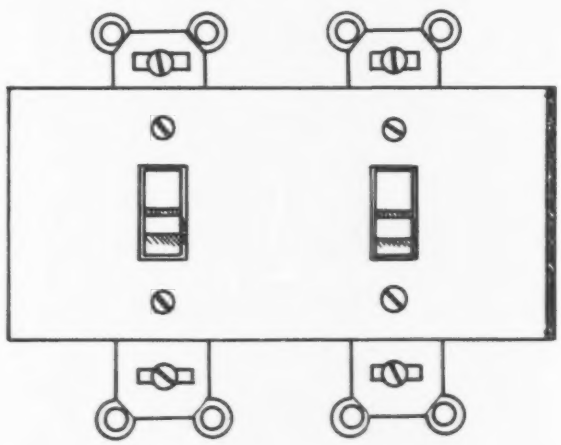


Plate cut down to allow devices to be secured in place while plate is held level

C. Remove plate

D. Tighten device securing screws

E. Reinstall plate

(NOTE: Check to make sure everything is square.)

JOB SHEET #10

F. Install plate

(NOTE: Be careful not to overtighten and crack the plate.)

ELECTRICAL BASIC SKILLS
UNIT IV

TEST

NAME _____ SCORE _____

1. List five rules for electrical installations.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

2. State ten basic electrical safety practices.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

   f. _____

   g. _____

   h. _____

   i. _____

   j. _____

TEST

3. Match to their correct definitions terms associated with switching situations. Write the correct numbers in the blanks.

_____a. Device used to open or transfer circuit direction

_____b. Conductor that supplies electrical energy to a switch

_____c. Conductor between light and switch when supply enters the light

_____d. Conductor that carries electrical energy from the switch to the load

_____e. Transfers conductors in a switching situation; used between 3-ways and 4-ways

_____f. Unit of an electrical system which is intended to carry but not utilize electrical energy

_____g. Metal strip which contains one or more devices

_____h. Threaded nipple used for hanging fixtures

_____i. Point of attachment for conductors

_____j. Piece of equipment used to secure cables

_____k. Written articles whose purpose provides minimum standards for safe installation and practical safeguarding of persons and property from hazards arising from the use of electricity

_____l. Unit of measure for electrical pressure

_____m. Unit of frequency equal to one cycle per second

1. Return leg
2. Device
3. Cable clamp
4. Hickey
5. Switch leg
6. Terminal
7. NEC (National Electrical Code)
8. Switch loop
9. Strap
10. Volt
11. Switch
12. Traveler
13. Hertz

TEST

4. List two requirements for terminal identification.

   a. _____

   _____

   b. _____

   _____

5. List two steps for grounding devices and boxes.

   a. _____

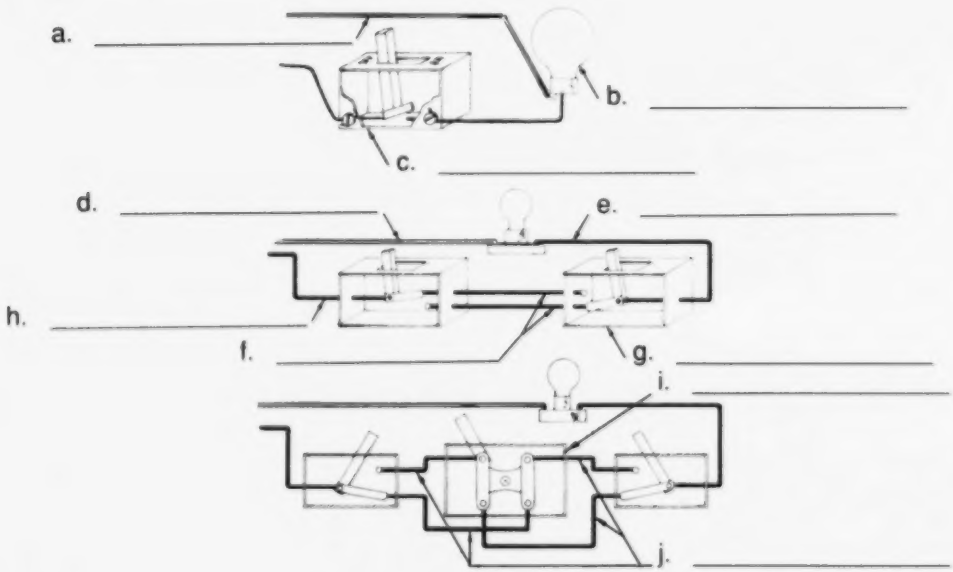
   _____

   b. _____

   _____

6. Identify parts of switching circuits illustrated below. Write the correct names in the blanks.

Single pole switch	**Switch leg**	**Four-way switch**	**Three-way switch**
Travelers	**Return leg**	**Lighting outlet box**	**Device bar**
Grounding conductor	**Neutral**	**Lamp**	



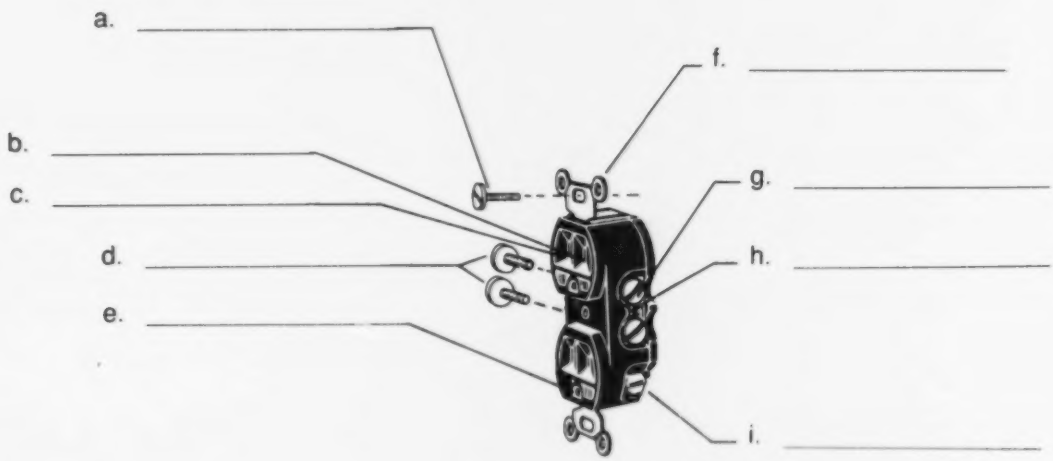
TEST

7. Match to their correct descriptions terms associated with receptacle outlets. Write the correct number in the blanks.

_____a. Current carrying conductors, both grounded and ungrounded, on a receptacle	1. Wires
_____b. Current carrying conductors and grounding conductors	2. Strap or yoke
_____c. Metal strip containing one or more devices	3. Multiple receptacle
_____d. Single device with two or more receptacles	4. Poles

8. Identify parts of a duplex grounding type receptacle illustrated below. Write the correct names in the blanks.

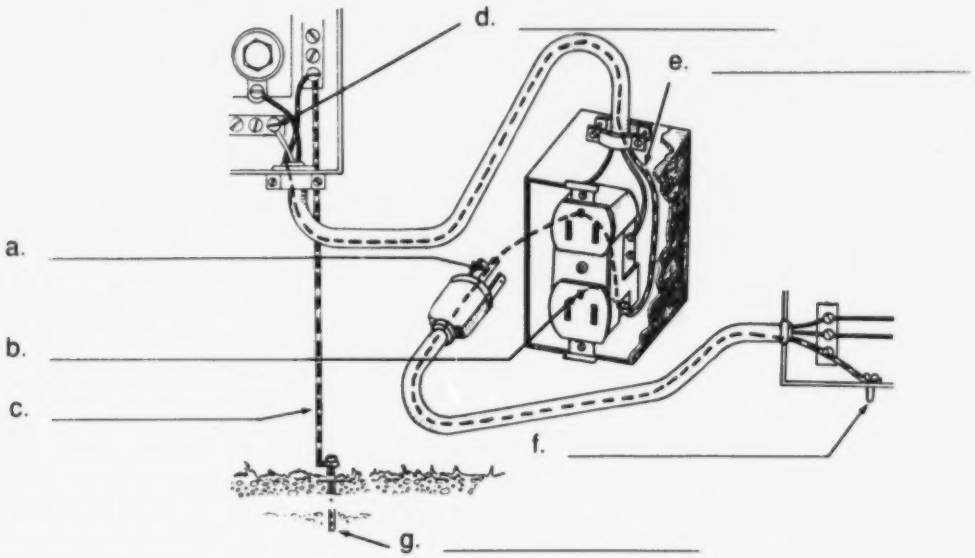
Mounting screw	**Ungrounded contact slot**	**Grounded terminal**
Ungrounded terminal	**Strap or yoke**	**Grounded contact slot**
Break-off fin	**Grounding contact slot**	**Grounding terminal**



TEST

9. Identify parts of the equipment grounding circuit illustrated below. Write the correct names in the blanks.

Attachment cap grounding prong
Grounding conductor
Neutral block
Grounding connection at appliance frame
Receptacle grounding slot
Grounding electrode
Grounding electrode conductor



10. List two NEC requirements pertaining to receptacles.

a. _____

_____

b. _____

_____

TEST

11. Match to their correct definitions terms associated with service installations. Write the correct numbers in the blanks.

_____a. Conductors and equipment for delivering energy from the electric supply system to the wiring system of the premises to be served

_____b. Service conductors made up in the form of a cable

_____c. Supply conductors that extend from the street main or from transformers to the service equipment of the premises to be supplied

_____d. Overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service entrance conductors at the building or other structure

_____e. Service conductors between the terminals of the service equipment and the point of the connection to the service lateral

_____f. Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop

_____g. Necessary equipment, usually consisting of a circuit breaker or fuses and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply

_____h. Underground service conductors between the street main, including any risers at a pole or other structure, or from transformers and the first point of connection to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall

1. Service conductors
2. Service entrance conductors, overhead service
3. Service drop
4. Service equipment
5. Service
6. Service entrance conductors, underground system
7. Service cable
8. Service raceway

TEST

_____i. Raceway that encloses the service entrance conductors

_____j. Conductor used to connect the grounding electrode to the equipment grounding conductor of the circuit at the service

_____k. Portion of a service raceway that extends through a roof or eave

_____l. Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage

9. Service mast
10. Roof-flashing
11. Grounding electrode conductor
12. Service lateral

12. Match the required clearance of service drop conductors to the various construction locations. Write the correct numbers in the blanks.

_____a. From final grade or other accessible surface

_____b. Over a roof with a slope of not less than 4 inches in 12 inches on systems which do not exceed 300 volts between conductors

_____c. Over commercial areas not subject to truck traffic

_____d. If the conductors do not pass over more than 4 feet of overhang and are terminated at a through-the-roof raceway or support on a system which does not exceed 300 volts between conductors

_____e. Over residential property, driveways and commercial areas when the voltage is 300 volts on the ground

1. 3 feet
2. 18 inches
3. 10 feet
4. 12 feet
5. 15 feet

13. State the maximum number of service entrance disconnects.

a. _____

b. _____

TEST

14. List four facts that should be known before service installation is started.

a. _____

b. _____

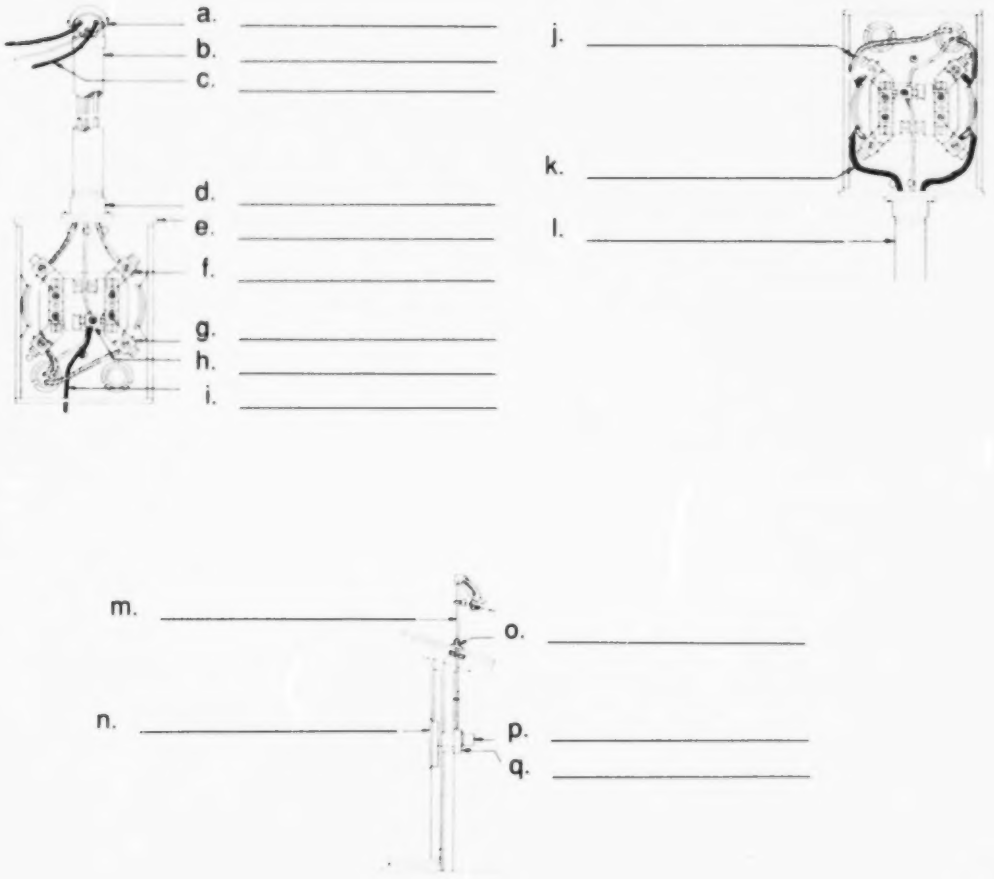
c. _____

d. _____

TEST

15. Identify parts of the service entrance illustrated below. Write the correct names in the blanks.

Service entrance weather head or cap
Grounding electrode conductor
Underground service raceway
Grounding lug
Service mast
Load lugs
Load center
Line lugs
Service entrance raceway
Service entrance conductors
Service lateral
Meter base
Roof saddle
Hub
Meter



TEST

16. Discuss briefly various types of grounding electrodes.

    a. Structural metal _____

    _____

    b. Water pipe _____

    _____

    c. Job made electrodes _____

    _____

    1. _____

    _____

    2. 8 foot lengths of —

        a. _____

        b. _____

        c. _____

    3. _____

    _____

17. Discuss briefly grounding electrode conductor installations and sizes.

    a. _____

    b. _____

        1. _____

        2. _____

        3. _____

(NOTE: Test question 18 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

18. Demonstrate the ability to:

    a. Wire a single pole switch controlling a single lighting outlet with the supply line entering the switch box

    b. Wire a single pole switch controlling a single lighting outlet with the supply line entering the lighting outlet box

TEST

c. Wire a three-way switching situation with the supply entering a single lighting outlet

d. Install a duplex grounding type receptacle

e. Install a multi-circuit, split-wired duplex grounding type receptacle

f. Wire a switch controlled, split-wired receptacle

g. Wire a receptacle fed from a lighting outlet through a single pole switch

h. Install an overload raceway with service entrance conductors to a meter base

i. Connect meter base assembly to load center or panel

j. Install plates on devices

ELECTRICAL BASIC SKILLS
UNIT IV

ANSWERS TO TEST

1. Answer should include any five of the following:

   a. Always be safety conscious
   b. Be sure all connections are secure and well insulated
   c. Always be sure that overcurrent protection is matched to your conductor rating
   d. Preform conductors before installing devices in boxes
   e. Use appropriate tools
   f. Always meet or exceed NEC and local code minimum installation requirements

2. Answer should include any ten of the following:

   a. Never underestimate the danger of 110 volt AC circuits
   b. Watch out for electrical arcs; they can cause bad burns
   c. Remember that mild shocks can cause personal injury or injury to others by your reaction
   d. Never install equipment that will overload a circuit
   e. Never bypass a fuse
   f. Be sure all electrical lines carrying current are well insulated
   g. Always check a circuit for voltage before servicing
   h. Work on live circuits only when absolutely necessary
   i. Use a neon test light or voltmeter to identify live circuits
   j. Stand on dry surface when working with live circuits
   k. Use only one hand if possible
   l. Wear suitable insulated hand covering
   m. Never keep tools lying around live conductors
   n. Return all tools to pouch when through working with them

3.

a.	11	e.	12	i.	6	m.	13
b.	5	f.	2	j.	3		
c.	8	g.	9	k.	7		
d.	1	h.	4	l.	10		

4. Answer should include any two of the following:

   a. All grounding terminals shall be green and hex headed
   b. Traveler terminals on three-way switches shall be the same color, and different from the controlling or common terminal
   c. Neutral conductors and terminals shall be white, silver, or labeled with the word "white" or the letter "W"
   d. Underground conductors are usually copper colored but could be any color other than those already designated

ANSWERS TO TEST

5. Answer should include any two of the following:

   a. Group and solidly connect all grounding conductors
   b. Connection shall be made from the grounding conductors to a green hex head screw or other device to ground all metal boxes
   c. Grounding terminals on devices shall be connected to metal boxes by a bonding jumper to metal boxes for flush installations
   d. On surface boxes the metal to metal contact between the device and box shall serve as the grounding bond
   e. In plastic boxes group the grounding conductors and connect them to the device grounding terminal

6. a. Neutral
   b. Lamp
   c. Single pole switch
   d. Neutral
   e. Return leg
   f. Travelers
   g. Three-way switch
   h. Switch leg
   i. Four-way switch
   j. Travelers

7. a. 4
   b. 1
   c. 2
   d. 3

8. a. Mounting screw
   b. Ungrounded contact slot
   c. Grounded contact slot
   d. Grounded terminals
   e. Grounding contact slot
   f. Strap or yoke
   g. Ungrounded terminal
   h. Break-off fin
   i. Grounding terminal

9. a. Attachment cap grounding prong
   b. Receptacle grounding slot
   c. Grounding electrode conductor
   d. Neutral block
   e. Grounding conductor
   f. Grounding connection at appliance frame
   g. Grounding electrode

10. Answer should include any two of the following:

    a. Single receptacles on individual branch circuits must be rated at least equal to the branch circuit
    b. Receptacles installed on 15 and 20 ampere branch circuits shall be of the grounding type
    c. Where practical to get a source of ground, replacement receptacles for nongrounding receptacles shall be of the grounding type

ANSWERS TO TEST

11.

a.	5	e.	6	i.	8
b.	7	f.	2	j.	11
c.	1	g.	4	k.	9
d.	3	h.	12	l.	10

12.
a. 3
b. 1
c. 5
d. 2
e. 4

13. Answer should include:

a. Not more than six switches in single enclosure or grouped on a switchboard
b. Not more than six circuit breakers in single enclosure or grouped on a switchboard

14. Answer should include:

a. Determine if underground or overhead service will be used
b. Amount of voltage and amperage service needed
c. Location where service conductors will enter the building
d. Size of service equipment needed

15.

a.	Service entrance weather head or cap	j.	Service entrance conductors
b.	Service entrance raceway	k.	Service lateral
c.	Service entrance conductors	l.	Underground service raceway
d.	Hug	m.	Service mast
e.	Meter base	n.	Load center
f.	Line lugs	o.	Roof saddle
g.	Load lugs	p.	Meter
h.	Grounding lug	q.	Meter base
i.	Grounding electrode conductor		

ANSWERS TO TEST

16. Discussion should include:

    a. Structural metal — Nearest available, effectively grounded structural metal member of the structure
    b. Water pipe — Metal water pipe shall be used when available
    c. Job made electrodes
        1) At least 20 feet of #4 or larger bare copper wire or 1/2-inch or larger steel reinforcing bar encased in at least 2 inches of concrete in footing
        2) 8 foot lengths of:
            a) 3/4-inch galvanized pipe
            b) 5/8-inch iron or steel rod
            c) 1/2-inch nonferrous rod
        3) At least 20 feet of #2 bare copper, 2-1/2 feet under grade encircling the structure

17. Discussion should include:

    a. Conductors and enclosures shall be secured to the surface they follow
    b. #6 or larger conductors
        1) Must be in conduit if subjected to physical damage
        2) If free of physical damage it may follow the surface of building if properly secured
        3) Aluminum or copper clad aluminum cannot be used in contact with masonry or earth

18. Performance skills evaluated to the satisfaction of the instructor